IX. *Experiments in Examination of the Peripheral Distribution of the Fibres of the Posterior Roots of some Spinal Nerves.*

By CHARLES S. SHERRINGTON, *M.A., M.D., Lecturer on Physiology, St. Thomas's Hospital, Professor-Superintendent of the Brown Institution, London, Fellow of Gonville and Caius College, Cambridge.*

Communicated by Professor M. FOSTER, *Sec. R.S.*

Received December 2,—Read December 8, 1892. Abbreviated March 2, 1893.

[PLATES 42–52.]

As a step preliminary to some observations on the reflex functions of the spinal cord of the Monkey, I have attempted to make a rather detailed examination of the distribution of the efferent and afferent roots of each spinal nerve, especially in the lower half of the body of that animal. I have recently published some experimental notes on the arrangement of some motor fibres in the lumbo-sacral plexus, and the present paper deals chiefly with the distribution of the afferent fibres of the roots.

PREVIOUS OBSERVATIONS.

In the researches which have had for their subject the peripheral distribution of the posterior roots of the spinal nerves, the plexuses of the Mammalian fore limb have been more studied than have those pertaining to the hind limb. With the exception of the five experiments extant by L. TÜRCK (1856), there seem no experiments on the cutaneous fields of the afferent spinal roots of the Mammalian hind limb previous to my own. This fact may lend interest to observations, especially on so high a type as the Monkey, and I take this opportunity of expressing my thanks to the Royal Society for pecuniary aid, placing that somewhat expensive laboratory animal within my reach.

Experimental inquiry into the subject appears to commence with C. ECKHARD (1)*, who appended to a research on the innervation of the muscles and movements of the hind limb of the Frog (1849) a brief note on the cutaneous distribution of the sensory roots of the four hindmost spinal nerves of that type. One general conclusion he drew, and it is as follows : "The field of skin to which a sensory root goes is not exactly that which overlies the muscles which are supplied by the corresponding motor root." ECKHARD cut the posterior roots only, and in the spinal canal; he divided all the roots of the region except the one whose field he wished to examine. The Frog was decapitated. Mechanical stimulation of the skin was employed, and the presence or absence of resulting movement taken as index.

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* The number refers to the number in the list of Literature of the Subject. See p. 647.

Four years later a second research on the subject appeared again from LUDWIG's Laboratory in Zurich, by PEYER (2). The Vth, VIth, VIIth, and VIIIth cervical and the Ist thoracic spinal nerves were investigated in the Rabbit. PEYER's method consisted in applying mechanical and thermal stimuli to the skin after section of all these nerves except the one under examination. The animal was narcotized by intravenous injection of opium. The spinal canal was not opened and the mixed spinal nerve was divided outside the vertebral column; it is important to note this because it is not easy to ensure *complete* section of the whole sensory root of the nerve outside the canal, and because by the section so performed the reflex will suffer by division of the motor part of the nerve as well as of the sensory.

PEYER's results may be epitomized as follows:—

The Vth cervical nerve receives sensory fibres from the skin of the front and inner side of the shoulder joint, and, from the lower and outer region of the neck as high as midway between the shoulder and the lower jaw.

The VIth cervical nerve receives sensory fibres from the skin of the front of the upper arm as far as its lower third; from the skin over the top of the m. anconæus externus and longus as far as the scapula; from the outer aspect of the shoulder, and the insertion of the m. lat. pectoris.

The VIIth cervical nerve receives sensory fibres from the skin of the front of the forearm as low as halfway to the wrist, from the flexure of the elbow, from the skin over the lower part of the m. anconæus long. as far as the olecranon; from the inner side of the upper arm and forearm, and from the thumb and 2nd digit, and corresponding edge of the manus and wrist.

The VIIIth cervical nerve receives sensory fibres from the skin of the outer side of the forearm, from the volar aspect of the manus, the 5th digit, and the volar and lateral aspects of the 2nd, 3rd, and 4th digits.

The Ist thoracic nerve receives sensory fibres from the back of the forearm, from outer side of the manus up to the middle line of the manus, and from the dorsal and volar aspects of the 3rd, 4th, and 5th digits.

PEYER concluded that in the skin of the limb the fields of the individual spinal nerves more or less overlap each other.

In 1865, W. KRAUSE (4), published an investigation into the distribution of the nerves of the fore limb. He used partly the reflex method and partly followed the degeneration of nerve-fibres after section of the nerves. In the Rabbit he found that section of the Vth and VIth cervical nerves did not cause degeneration in any of the finger nerves The VIIth cervical was not tested by degeneration, but KRAUSE concluded from the reflex method that it does not, as PEYER had stated, supply the finger and thumb.

KRAUSE stated that just as with the motor roots so also with the sensory, the parts nearest the hand are supplied by the brachial roots lying furthest from the head-end of the cord. He stated of the Ist thoracic and VIIIth cervical roots that their distribution in the skin is so arranged that the VIIIth supplies the radial side of the hand, the Ist the ulnar side, and that the skin fields of the two are separated by a sharp line, running from the tip of the 4th digit. He also stated that each myelinated nerve-fibre contained in a spinal nerve-root stands in fixed relation with a definite anatomical point of the periphery, which point is in all individuals the same. He stated as VOIGT had (8), that variation affects only the course of the fibres between the centre and the periphery, the terminations themselves central and peripheral, remaining invariable. This important conclusion, which contradicts the observation by C. ECKHARD, is certainly erroneous for the motor roots. KRAUSE also stated "that a muscle is supplied with nerve-fibres by the same spinal nerve that innervates the skin overlying it." And this statement controverts the previous one by ECKHARD quoted above. KRAUSE employed for one experiment a Monkey (*Cynomolgus*). He severed the trunk formed by the VIth and VIIth cervical roots, and found in 14 days time no degeneration in the digital nerves of the hand.

In 1868, KOSCHEWNIKOFF (5), examined the cutaneous distribution of the spinal nerves to the hind limb of the Frog, and his results agree well with those recorded in the note by ECKHARD. He found that the fields of distribution of the nerve-roots vary somewhat in different individuals. The VIIth root supplies the outer half of the thigh, knee, and top of the leg. The VIIIth root supplies the inner half of the thigh, the outer part of the knee, the calf, and the whole of the foot. The IXth root supplies the inner side of the thigh, the ham, the inner side of the leg, and the whole of the foot. The skin in most regions of the limb is supplied therefore by two nerve-roots. KOSCHEWNIKOFF used the "reflex" method as ECKHARD had done.

The next research was by C. MEYER (6) and based entirely on the degeneration method. In five Frogs the VIIIth spinal nerve, in three Frogs the IXth spinal nerve was severed, outside the spinal canal, and the degeneration in the peripheral nerves resulting after an interval of about 100 days was studied by the microscope. MEYER'S conclusion is that "in the hind limb of the Frog the territories of the VIIIth and IXth spinal nerves are not so exactly and sharply limited as has been shown by KRAUSE to be the case with the two lowest spinal nerves of the brachial plexus of the Rabbit."

The most important work on the distribution of the posterior spinal nerve roots to the skin is that by TÜRCK. His results have suffered from the circumstances of their publication. In 1856, his work had advanced so far that he was able to issue a preliminary account of them in that year (3), but after that time the calls of his professional career were so great that at his death he left the research unpublished and still incomplete. Two years after his preliminary account had been given, the conclusions stated in it were largely incorporated in LUDWIG'S 'Handbuch der Physiologie'

(2nd edition), and two figures are there given in illustration of them. After TÜRCK's death the papers and drawings pertaining to his research were collected and published in 1868 as a *Denkschrift* (7). This posthumous issue was edited by C. WEDL. Much of it is difficult to understand, but the minute care obvious in the fragments will be recognized by anyone who turns to them for reference. The scale on which the work was projected can be gathered from the fact that at TÜRCK's death written records, illustrated in most instances by drawings and by *post-mortem* notes, of more than 350 clinical cases bearing on the question came into the hands of the late Professor DUCHEK. TÜRCK experimented only on the Dog. He divided the spinal nerves outside the vertebral column and, conversely to PEYER, ECKHARD, and KOSCHEWNIKOFF, severed only the spinal nerve which he desired to examine. He tested the sensibility of the skin by pinching it. The number of TÜRCK's experiments extant in the posthumous paper is twenty-five. Of this number twenty were upon the brachial plexus; the remaining five upon the lumbo-sacral. The difficulty of understanding the experimental notes and the drawings left by TÜRCK is partly due to their brevity and to the variation found in different individuals. Partly it is due to the terminology which he considered it advantageous to employ. I will quote his inductions before epitomizing his facts, in order that his terminology may be clearer. He does not appear to have examined the trunk apart from the region abutting on the limbs.

The area of distribution of each nerve-root in the neck and trunk is shaped like a band which runs round from the vertebral column to the ventral middle line in a direction at right angles to the long axis of the body. The areas of distribution of the spinal nerves supplying the skin of the extremities follow, with some modification, the same plan as the other spinal nerves. Their agreement with the others is, however, only apparent when the limbs are brought into a certain position with relation to the trunk. For the anterior extremity this position is when the limb is at right angles to the trunk, fully extended at all its joints and with the hand somewhat supine. The areas of distribution of the limbs behave as if they originally ran round the sides, as in the neck and trunk, and had been displaced by the sideward extension of the limb. Some that have remained attached to the middle lines have been ruptured across, *e.g.*, the IInd and IIIrd thoracic areas. Each spinal nerve has an area of skin belonging to it which is supplied by it *exclusively;* many of the spinal nerves have besides a field of skin exclusively their own, a field which they, in *common* with some other spinal nerves, supply. The nerves of the extremities have no exclusive areas, but only common ones. The nerves of the neck and trunk have very large exclusive areas and very small common areas; it is questionable whether some have any common areas at all.

As TÜRCK's details are important and not very well known, I will abstract them here at some length.

Area of the IVth Cervical Nerve of the Dog.—Anterior border: from the back of the occiput to midway between the sternal notch and the cricoid. Posterior border: from the VIth cervical spinous process to the sternal notch.

Area of the Vth Cervical of the Dog.—Posterior border: from the Ist thoracic spinous process to the top of the sternum, passing over the supraspinous fossa of the scapula and the point of the shoulder.

Area of the VIth Cervical of the Dog.—Exclusive area: bounded above by the area of the Vth, and stretching under the extensor side of the shoulder joint to end in a narrow point some distance above the flexure of the elbow. Common area with VIIth.

Area of the VIIth Cervical of the Dog.—No exclusive area. Common area with VIth and VIIIth. Touches the lower border of the area of the Vth above on the scapula, and passes below the exclusive area of the VIth, spreading over the middle part of the outer face of the upper arm, and over the outer face of the elbow, the radial side and part of the inner surface of the wrist, thumb, and first phalanx of the 2nd, 3rd, and 4th digits. The upper part of this area is common to VIth and VIIth, the lower to VIIth and VIIIth.

Area of the VIIIth Cervical of the Dog.—No exclusive area. Three common areas: α, with VIIth (above described); β, with Ist thoracic; γ, with VIIth and Ist. Area β extends along the ulnar side of the outer surface of the forearm, wrist, and metacarpus; it includes the 5th digit, the web between the 4th and 5th digits, the outer side of the volar face of the 5th digit, and the outer third of the thenar eminence. Area γ lies between α and β. It includes the middle of the palm and the upper part of the outer side of the forearm.

Area of the Ist Thoracic Nerve of the Dog.—In addition to the above described common areas it has an exclusive area, which extends along the ulnar side of the forearm to near the wrist, and includes the inner condyle.

Area of the IInd Thoracic of the Dog.—No common areas, but two exclusive areas detached one from the other, α and β. Area α, from the 2nd thoracic vertebra over the end of the infraspinous fossa, and then as a band over the thorax and along the outer fold of the axilla to the back of the upper arm and down to the elbow. Area β, a rectangular patch over the 2nd costal cartilage.

Area of the IIIrd Thoracic of the Dog.—No common areas, but two exclusive areas detached one from the other, α and β. Area α, from the 3rd and 4th vertebræ across the back, down the posterior face of the upper arm nearly to the elbow; then over the upper part of the axilla and round the chest. Area β, a patch on sternum at the 4th costal cartilage.

Area of the IVth Thoracic of the Dog to the XIIIth inclusive.—Band-like areas round the body.

Area of the Three Highest Lumbar Nerves of the Dog.—Is a band-like strip extending from the lower edge of the area of the XIIIth thoracic to half-way down the iliac crest behind. It sweeps from not quite up to the middle line of the back to extend toward the middle line of the hypogastric region, but falls short of it, the IIIrd falling farther short than IInd, the IInd than Ist.

Area of the IVth Lumbar of the Dog.—A broad strip from the lower half of the sacrum over the trochanter major down the outside of the thigh round the knee, up the inner side of the thigh, upwards to the abdomen, so as to include the skin of half the penis, but not of the prepuce.

Area of the Vth Lumbar of the Dog.—Has an *exclusive* area, which covers part of the outer side of the knee, the inner side of the leg to below the inner side of the ankle, but barely reaching the inner border of the leg. Has also an area in common with the VIth lumbar, which includes the flexor aspect of the ankle, the back of the foot to the 1st digit, and the inner edge of the foot.

Area of the VIth Lumbar of the Dog.—Has no exclusive area, but two common areas, α (in common with VIIth lumbar), from below the knee narrowing down the outer side of the leg, and over the front of the ankle to the dorsal aspect of the toes. β (in common with Vth lumbar), described under Vth.

Area of the VIIth Lumbar of the Dog.—Has no exclusive area, but two common areas, α (in common with VIth), described above. β (in common with Ist sacral), from the ham to the sole, passing over the outer side of the ankle.

Area of the Ist Sacral of the Dog.—(No written description is extant in TÜRCK'S papers, but from the sketches it has a common area (with VIIth), and an exclusive area on the outer surface of the thigh.

Area of the IInd Sacral of the Dog.—Extends from the middle line of the perinæum, not, however, reaching the root of the tail or the anus, round the scrotum or vulva.

Area of the IIIrd Sacral of the Dog.—An area at the side of the root of the tail, including posteriorly the anterior border of the anal orifice.

Area of the IVth Sacral of the Dog.—Smaller than IIIrd, and including the posterior part of the anus.

When we remember the importance of this research, and that it was first published nearly forty years ago, it appears remarkable that its results are not more a part of our common anatomical knowledge than they are.

A paper by HERRINGHAM (10) in 1887 is an important contribution to knowledge on the present subject, although it deals by dissection with the upper limb and not with the limb which is the subject of this paper. Of the details furnished by HERRINGHAM concerning the root-composition of the nerves of the hand I must postpone mention to a paper I hope to publish shortly on the sensory roots of the upper limb. They are chiefly interesting here because they do not confirm the conclusions put forward in KRAUSE'S above-mentioned research. Concerning HERRINGHAM'S "law," "that any given fibre may alter its position relative to the vertebral column, but will maintain its position relative to other fibres," I have, in a recent paper, drawn attention to the importance and correctness of this law as regards the motor supply to the musculature of the limbs. Concerning the sensory spinal roots and the upper limb HERRINGHAM formulated two rules; "Of two spots on the skin, that which is nearer the preaxial border tends to be supplied by the higher nerve." "Of two spots in the preaxial area the lower tends to be supplied by the lower nerve, and of two spots in the postaxial area the lower tends to be supplied by the higher nerve." These important inductions agree with the arrangement discovered by TÜRCK, and are the more corroborative because HERRINGHAM was apparently unacquainted with the results obtained by TÜRCK.

Concerning the clinical observations elucidating the localizations of the sensory fibres of the spinal segments I regret I can here only briefly refer to them. A valuable collection of them exists in THORBURN'S "Surgery of the Spinal Cord" (17), and in the recent paper by ALLEN STARR (18), founded partly upon his own observation and clinique. An important clinical contribution toward an interesting aspect of the subject has been still more lately made by J. MACKENZIE (19) in his 'Sensory Symptoms associated with Visceral Disease.' In the present month Dr. H. HEAD (20) has communicated to the Neurological Society of London an able paper illustrating the topography of pains, referred to the cutaneous fields of the spinal segments in consequence of visceral irritation, and often as features of functional disease. A glance at the figures furnished by these observers suffices to show more than a mere general correspondence between the skin-fields revealed in Man to clinical observation, and those of *Macacus rhesus*, the subject of this paper. I think there is little doubt that a close correspondence between the Human lumbo-sacral plexus and that of *Macacus* exists upon the following basis :—*

Macacus rhesus.	Man.
IInd lumbar	Ist lumbar
IIIrd ,,	IInd ,,
IVth ,,	IIIrd ,,
Vth ,,	IVth ,,
VIth ,,	Vth ,,
VIIth ,,	Ist sacral
Ist sacral	IInd ,,
IInd ,,	IIIrd ,,
IIIrd ,,	IVth ,,

Before concluding these remarks mention must be made of the luminous essay by Ross (16) "On the Segmental Arrangement of Sensory Disorders." Brief and largely devoted to theoretical considerations as it is, that essay will probably live to be considered the germ of much future research on lines indicated by the suggestions it contains. Its author, like Féré (9) and Herringham (10), was evidently unaware of Türck's results, and had he been aware of them the details of his scheme of cutaneous segmentation would doubtless have approached accuracy even more nearly than it does. A salient merit of the essay seems to me the boldness with which to clinical observation it applies the fundamental generalizations obtained by Paterson (11, 12, 13, 14) from embryological inquiry and from study of the limb plexus in its development.

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FROG (*R. temporaria*).

The method of investigation employed on the Frog has been as follows :—

Summer Frogs were used. When the animal had been chloroformed under a bell jar, the cerebral hemispheres were carefully exposed through a small trepan hole (Pasteur's 3 millim. trephine), the centre of which lay in the median line. The hemispheres were then completely removed, hæmorrhage being avoided by not using the scissors too freely at the lateral borders. The lowest vertebræ were then exposed and rather completely cleaned of overlying tissue ; one point of a strong though small pair of scissors was then inserted carefully under the left edge of the last vertebra but one, and the lamina cut. The rest, as far as required, were then easily divided by extending the incision, and then the right-hand side (that of the nerve-roots used) was proceeded with. In fact the procedure was that described by C. ECKHARD (1). In one experiment a short incision parallel to the coccyx was made, exposing the four lowest nerves outside the canal, and then all but the desired one was divided. This method, that used by C. MEYER (6), has the disadvantage of not insuring possible twigs of communication between nerve and nerve proximal to the point of section. Further, for my purpose, it limited the field of reply by unnecessary section of the motor roots. In the spinal canal the afferent roots only were divided, and of them, all but the one immediate under examination.

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* Also the Jacksonian Essay, 1892.

† Published in 'Brain,' vol. 16, p. 1, May, 1893.

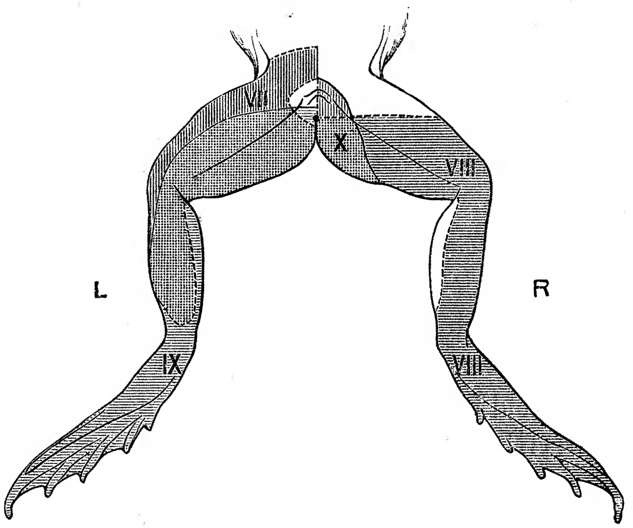
The surface of the hind limb and adjacent part of the trunk was then explored, and the points from which *reflex movements could and could not be initiated* were ascertained. It was assumed that each spot of surface, from which no reflex movement could be elicited, had lost its nervous connection with the spinal cord, and, therefore, did not receive supply from the roots remaining unsevered. The mode of excitation used in the earlier experiments was application of weak induction currents of rapid series. But this plan was soon discarded for stimulation by bits of blotting paper steeped in water acidulated with dilute sulphuric acid. The bits of paper were circles 2 millims across. Mechanical excitation by compression was also employed. During the exploration the Frog was suspended by soft cotton bands under the axillæ, the hind limbs hanging freely. At first my experiments consisted in cutting through a particular nerve-root, and then exploring the limb surface to find a corresponding area of anæsthesia. It soon became clear that the occurrence of muscular movement was more reliable evidence of the existence of afferent ties between the cord and the portion of surface under examination, than was absence of reflex movement an evidence of the non-existence of such ties. In the later experiments, the plan adopted was division of the dorsal nerve-roots immediately above and below the root to be examined; the limits of the area from which a reflex movement could be elicited (*the field of response*), were then determined, and taken as an index of the distribution of the afferent filaments. Each point, whence a reflex movement was initiated, was entered at the time upon a plan of the skin surface previously prepared.

By these methods the field of cutaneous distribution was determined for the dorsal roots of the VIIth, VIIIth, IXth, and Xth spinal nerves respectively, with the following results (figs. 1 and 2):—

VIIth Spinal Nerve.—The anterior border of the cutaneous field passes almost horizontally round one half of the abdomen from a point in the median line of the dorsal aspect to a point somewhat further back in the median line of the ventral aspect. The area embraces the abdomen behind this line, and usually the whole of the thigh, extending also over a tongue-shaped area in the leg that usually nearly reaches the angle. The posterior border of the field passes, therefore, from the middle of the ham over the top of the gastrocnemius to the shin, and reaches the peroneal aspect of the anticus, returning on itself just above the outer malleolus, and following the peroneal edge of the gastrocnemius to the ham. There is also an area around the end of the coccyx and the orifice of the cloaca which is not supplied from the VIIth root. The edge of this area is also part of the posterior limit of the cutaneous field of the VIIth root. The shape and extent of the whole cutaneous field will be gathered better from figs. 1, 2, than from a verbal description. The figures were drawn from the sixth experiment of a series of nineteen made on this root, and are representative of the area as usually existent. There is certainly some variability of the area in individuals. The variation is generally slight, but may be great. When the area was smaller than usual, twice it was found that a strip of the posterior aspect of the thigh along a line roughly corresponding with the course of the sciatic nerve was hardly included, *i.e.*, was continuous with the crural area, whence no reflex could be evoked. On the other hand, in three individuals the whole of the skin of the pes, both dorsal and plantar, especially the former, was supplied by the VIIth root. The risk of error was eliminated by employment of mechanical stimulation; a touch on the dorsum was sufficient to cause flexion of the hip.

VIIIth Spinal Nerve.—The anterior border of the cutaneous field of this nerve runs from near the orifice of the cloaca outward along the back of the thigh, reaching nearly to half way down the front of the thigh, and then sweeping up over POUPART's ligament to the symphysis, or a millimetre above it. Below that border the whole of the limb, except a longitudinally directed oval area over the calf, is included in the distribution of the nerve. The distribution of the root has been mapped out in ten experiments, and but little variation was detected; once the field of its supply included the crural region, if not entirely, very nearly so. The immediate vicinity of the posterior end of the coccyx was never included; but the side and ventral edge of the cloacal orifice was part of the ordinary field of the nerve.

Fig. 1.

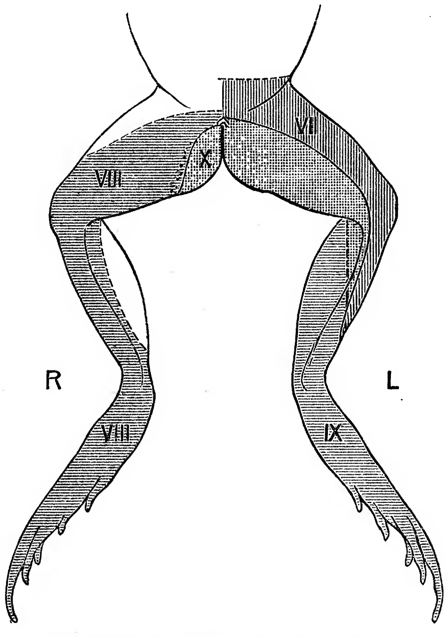


Rana temporaria (dorsal aspect).

IXth Spinal Nerve.—The anterior border of the cutaneous field of the dorsal root of this nerve may be represented by a line starting from the middle line of the back, about midway between the cloaca and the coccyx, and passing outwards and downwards along the posterior aspect of the thigh and knee, to reach the shin about half-way down the leg, and thence be reflected on itself so as to ascend the limb along the inner side of the knee and the ventral aspect of the thigh to the middle line of the hypogastrium at the symphysis pubis, about a couple of millimetres behind the anterior edge of the field of the VIIIth root. The field was delimited in eleven experiments, and no great amount of variation in it detected.

Xth Spinal Nerve.—The cutaneous field of the dorsal root of this nerve is smaller, as is the root itself, than those of the other three nerves examined. It is a tongue-shaped area, the edge of which is represented by a line which starts from the middle line of the back just in front of the coccyx, and passes downward over the hip joint to the back of the thigh, extending about half-way to the ham, and thence returning upward to the middle line of the body below the symphysis pubis. A large portion of this boundary corresponds accurately with the edge of a piece of skin of different character from the skin elsewhere, and beset with glands of a special kind—skin which is modified by sexual character. This field has been delimited in a number of experiments (more than twelve), and has been found to vary considerably, and the size of the patch of sexual skin is also variable. The patch of sexual skin sometimes exceeded the limits of the field of the nerve.

Fig 2.



Rana temporaria (ventral aspect).

The fields of distribution, as thus given, were ascertained at the very outset of the present investigation, and before I had come across the paper by ECKHARD. After reading that, I repeated the delimitation again for each nerve, paying attention to the discrepancies between his description and the above, but found nothing to prevent adherence to the areas, as previously determined and represented in the combined figures given.

The conclusions arrived at by the above examination of *Rana temporaria* proved a basis for the succeeding examination of *Macacus rhesus* and the Cat. I will therefore state them here before proceeding with the description of those other types.

1. Although in a plexus each nerve-root affords contributions to many different nerve-trunks in the plexus, the cutaneous distribution of the root is composed not of patches which are disjoined, but of patches which are so joined that the distribution of the entire root forms one continuous field.

2. The field of skin belonging to each sensory spinal nerve-root overlaps the skin-fields of the neighbouring spinal nerves to a remarkable extent. The disposition of the overlapping is such that the cutaneous field of one sensory root overlaps, to a certain extent, the cutaneous field or fields of the sensory root or roots immediately in front of it, and, to a certain extent, the field or fields of the sensory root or roots immediately behind it. These two overlaps may be termed respectively the *anterior overlap* and the *posterior overlap* of the root-field.

3. The cutaneous field for each posterior root meets the middle line of the body both ventrally and dorsally. Although the transgression of the middle line of the body by the root-field is but slight, yet in most places a slight transgression is unmistakable. A *crossed overlapping* of the cutaneous fields of the right-hand and left-hand posterior roots is thus existent. This *crossed overlap* of the root-fields at the middle line may, on the dorsal aspect, be termed the *dorsal crossed overlap*, on the ventral aspect the *ventral crossed overlap* of the root-field.

4. As judged by its nerve-root supply, the skin at the posterior end of the coccyx is segmentally posterior, even to the skin surrounding the cloacal orifice. Of the skin of the limb, that on the extensor aspect (front) of the thigh is segmentally anterior to the skin of the leg or foot, but that on the flexor aspect (back) of the thigh is of the same segmental level as that of the foot. The most segmentally posterior portion of the skin of the limb is the sexual patch above described.

During the above experiments it was found that in the cutaneous field for each root the peripheral portion of the field was not so irritable as the rest of the field. The edge of the field had no abrupt limit, but the irritability gradually faded at the border zone. Therefore :—

5. In the cutaneous field of each single root the distribution of the particular root is less abundant at and near the edge than elsewhere in the field. The edge of the field is less abrupt at the anterior and posterior overlaps than at the crossed overlaps.

It was clear from the experiments that much individual variation exists in the extent of the cutaneous fields of the sensory roots. This was particularly seen with the Xth and VIIth roots. It is a phenomenon quite similar to that already noted for the motor distribution of these spinal nerves in the Frog by ECKHARD (1), HALLSTEN[*] and myself[†] and, in the Cat and Monkey by LANGLEY[‡] and myself.[§] In a paper on the arrangement of the motor fibres of the lumbo-sacral plexus, I have, for convenience of reference, treated this individual variation as giving two classes of plexal distribution, a *prefixed* and a *postfixed.* This classification will save periphrasis in the present paper also, and is as applicable to the sensory nerve-roots as to the motor. In an individual with prefixed plexus any particular area of skin is supplied by nerve-roots which lie further headward than those supplying the correspondingly situated skin in an individual with postfixed plexus. For example, in an individual with prefixed plexus, the skin of the dorsum pedis will receive fibres from the VIIth and VIIIth roots; in an individual with postfixed plexus, from the VIIIth and IXth roots only. Not only may the nerve-trunks of the plexus in the former case be called prefixed, in the latter postfixed, but the skin of the dorsum pedis may be also termed prefixed and postfixed, because connected to the spinal cord more anteriorly in the former individual, more posteriorly in the latter. I insist on this because it appears that a plexus which may be prefixed as regards its efferent roots may not be so as regards its afferent, and *vice versâ* (*cf.* my previous paper). Thus, root VII may be distributed to the skin of the foot, the plexus being, then, as regards its afferent fibres, prefixed; root VII may supply not merely thigh muscles but the pre-tibial, or even the post-tibial muscles, as shown in my previous paper, the plexus being in the latter case prefixed as regards its efferent fibres. On three occasions, having found a root VII distributed to the whole of the skin of the foot, I have examined its distribution to the pre- and post-tibial muscles; twice the root did not supply either of those muscle-groups; so that in two individuals out of the three tested a plexus, with markedly prefixed afferent fibres, was not markedly prefixed in regard to efferent fibres. The skin was "prefixed" in the same limb in which the muscle was not. And I have met one instance in which, although root VII supplied the tibialis anticus muscle, the skin field of that root did not extend lower than usual, *i.e.*, the muscle was prefixed but not the skin. On the other hand, I have seen (*e.g.*, in the third of the three individuals above referred to) an afferent distribution of the prefixed class co-exist with an efferent distribution of the prefixed class, and although the number of my experiments is too small to be a secure guide in the matter, I am led to believe that when the afferent fibres of the plexus are prefixed (or postfixed) usually the efferent are so also. The variation of root attachment to the cord, and the possible independence of the anterior and posterior roots of the same individual in this respect, might perhaps be accounted for by the growing *out* of anterior root into myomere, &c., the growing *in* of posterior root into cord segment. A slight difference of ratio of growth of cord to growth of its circumjacent tissue might involve a measurable variation in the root attachment of different individuals. Such an hypothesis would also explain HERRINGHAM's law that the variation affects a series of roots and not a single root.

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[*] 'Archiv. f. Physiol.,' 1885, p. 167.

[†] *Loc. cit.*, vol. 13, p. 638.

[‡] 'Journal of Physiology,' vol. 12, p. 366.

[§] *Loc. cit.*, pp. 639 and 753,

Although the afferent and efferent divisions of the spinal nerve often exhibit variation independently one of another, no instance was met in which the variation did not appear to apply equally to both right and left sides of the body. In other words, though there is considerable variation in the extent of the skin-fields of the separate roots in different individuals, the pattern of distribution was in every individual bilaterally symmetrical.

The rule enunciated by PEYER (2) that the muscle is innervated by the spinal root which innervates the overlying skin is seen to be sometimes true, but subject to not inconsiderable exceptions. Thus the gastrocnemius muscle supplied by roots VIII and IX, may be covered by skin supplied from VII, VIII, and IX; or the tibialis anticus may be supplied by VII, VIII, IX, and be covered by skin innervated only from VIII and IX.

METHOD OF OBSERVATION EMPLOYED ON CAT.

By exciting in an anæsthetized animal the central end of a nerve trunk containing afferent nerve-fibres, reflex actions of various quality and degree may be initiated. By severance of the afferent rootlets of the spinal nerve or nerves by which a peripheral nerve-trunk is connected with the cord the reflexes originated through it can be diminished or set aside completely; diminished if the peripheral trunk communicate with the cord through the channel of several roots and one but not all of these be severed, set aside completely if the severance include all the lines of the connection. This plan of observation was adopted for the exploration of the spinal connections of the afferent nerve-trunks of the lower limb in the Cat.

Choice of a Reflex.—It is evidently desirable for the purpose to choose as criterion of the existence of afferent nerve-fibres a reflex the quantitative amount of which is at least roughly estimable, a reflex not easily fatigued by repetition, not liable to be occasioned by extraneous occurrences during an experiment nor to be simulated by nervous actions arising intrinsically, and, above all, a reflex capable of being evoked to a clearly detectible extent by excitation even feeble in character. Some trial experiments convinced me that the reflex I had looked forward to as probably the most satisfactory was not so; I had thought that in the arterial blood-pressure, admitting as that does of continuous graphic record, and affected as it is by many afferent channels, a most suitable index could be obtained. However, as my friend Dr. ROSE-BRADFORD early foretold me, it proved unsuitable, and for several reasons. In an afferent limb-nerve excitation sufficient to cause a marked reflex contraction in the musculature of the limb often leaves the blood-pressure trace completely without alteration; the difficulty of maintaining the anæsthesia at so constant a depth that the mean arterial pressure remains the same from half-hour to half-hour is very great; the experiment involves frequently cutting large nerve-roots, and this, with the usually somewhat severe operation and the prolonged employment of the anæsthetic, combines to induce a tendency to Traube-Hering undulations, destroying the regularity of mean pressure desirable in the detection of transient reflex elevations and depressions. Another reflex sign elicitable is alteration of size of the pupil (SCHIFF,* OTT†), but under anæsthesia the pupil soon becomes widely dilated and sluggish, and a short trial sufficed to show that as a sign it is neither reliable nor easily legible. Modification of the respiratory rhythm induced by excitation of an afferent limb-nerve was next tested as a guide. It was found more delicate in this respect than either arterial pressure or size of pupil, but it appeared less amenable to excitation of the great sacral roots than to that of the lumbar, especially of the upper lumbar. Indeed, it became evident, when experimenting on respiratory reflexes, that local muscular movement was the least variable and the most obvious evidence of the arrival of impulses in the cord by afferent fibres from the *limbs* and body wall, and that the *occurrence* of the local movement was a more reliable token than was the *absence* of it, considered as a negative.

The locality of the reflex movement varies with the locality of source of the afferent impulses, and the intensity of them. With weak stimulation the movement tends to be confined to the muscles innervated by the same spinal segment irritated,‡ but it also tends to appear with especial ease in the muscles antagonistic to those, even when of other segments. When the central end of the external saphenous nerve is excited by currents somewhat stronger than, if applied to the posterior tibial trunk, would produce contraction of the gastrocnemius, contraction of the gastrocnemius is evoked, and the contraction of the gastrocnemius may be apparently limited to one head of the muscle if the currents employed be of minimal efficiency. Somewhat stronger excitation produces a reply less locally restricted but still distinctly local in character. These limited reflex movements can be evoked from pure muscular nerves, *e.g.*, the nerve-twigs entering muscles. From the central end of the nerve entering the outer head of the gastrocnemius a contraction of the outer head of the muscle can be obtained which is immediately cut out by severance of certain roots in the spinal canal. So quick appears the reply thus obtained, that it was for some time disregarded, as I thought it but an example of the "paradoxical" contraction. On some occasions it may have been of that nature, but more frequently it ceased directly the posterior roots were severed in the spinal canal. Attention has been called recently to such reflex movements by CHAUVEAU;§ in the present paper I refer to them merely as constituting the criterion which was employed as best for my purpose, because delicate, readily detectable, and practically unexhausted by the course of experiment.

My experiments were conducted as follows:—The animal was wrapped in cotton wool with the exception of the head and back. The back was shaved and one of the limbs in the region to be examined. The animal was then deeply anæsthetized, and placed on a warm water stage upon the operating table. The spinal cord was then in requisite length exposed in the vertebral canal by removal of a sufficient number of spinous processes and laminæ. The dura mater is usually covered in the lumbar region by a layer of fat, in which there lie embedded largish veins. When this layer is turned back by a blunt "seeker" the cord is seen through the transparent membrane, and the pulsation of the vessels on it is very obvious. A little further preparation suffices to bring into view the nerve-roots at their emergence from the dural sheath. The nerve-root can be divided outside the dural sheath or inside it. The former plan has the advantage of not letting out much of the cerebro-spinal fluid, a condition of prime importance for the prolonged preservation of the normal state of the cord. The latter plan has the advantage of presenting no difficulty to severance of the whole of the afferent root of the spinal nerve without injuring the efferent root, whereas if the severance be made outside the theca, it is, in order to be certain that the whole afferent root is divided, best to sever the entire spinal nerve trunk altogether, and this entails a reduction of the efferent field for motor play by a part. In my experiments, unless otherwise stated, the root was cut inside the theca, and the afferent portion alone was severed. Before carrying out the section of a nerve-root it is important to pass a thread round the root in order to ensure the inclusion of all the root filaments in the section. The large nerve-roots of the lumbo-sacral region are accompanied by veins proportionately large, which may after section give sufficient hæmorrhage to obscure the position of the root; it is therefore necessary to perform the desired section at one closure of the scissors. After the section a pledget of wool with normal saline at 38° C. is laid over the cord, and the soft parts are brought together with accurate adjustment. The peripheral nerve, the root constitution of which is to be examined, is then rapidly exposed at a suitable point through a small incision. Beneath it two threads are carefully laid, the more distal is tied, and the trunk divided just distal to it. The other ligature is drawn tight, and the character of the resulting reflex movement noted. Then one of the nerve-roots already exposed in the vertebral canal is severed, and again the nerve-trunk excited by tying a thread ligature. If, as before, the local movement follow in a clear manner, the test is considered to have given an affirmative, and another root is proceeded with by section. If the local movement is not clearly obtained, the test is repeated with a second ligature applied to a point rather higher up the nerve than was the former one. If a local movement is again not clearly obtained, the trunk is well cleared from tissue with the scissors, and lifted up to sheathed electrodes, and weak induction shock in series of a rate of 100 per second are applied. If this stimulation is followed by no movement even when strong enough to be distinctly unpleasant to the tongue, then it is considered that the afferent connections of the peripheral trunk with the cord had been broken completely through. On the other hand, directly a clear local movement has been observed to follow the excitation, the test is considered to have replied that the nerve has probably still afferent connections with the cord, and another of the spinal roots already exposed is severed. If this severance is immediately followed by inability to re-obtain the movement elicited before, or, indeed, any movement with the strength of stimulus previously employed, it is considered that the previous movement was truly reflex, and that at the last root-section the nerve-trunk under examination lost its last afferent connection with the cord. In each experiment the sections of the posterior roots were made successively in an ascending direction or successively in a descending direction, unless expressly stated otherwise. In most cases in each experiment the corresponding peripheral trunk of the right and left sides was examined at a corresponding point both right and left, and on the right hand the roots were severed in the ascending direction, on the left hand in the descending direction. The result on the right side gave for the individual the upper limit of root connection of the trunk examined, the result on the left side the lower limit for the connection. By observing the difference in the strength of excitation required to elicit the reflex before and after intermediate sections of roots, it was possible to judge roughly the share which the root took in the composition of the peripheral trunk. But the indication so obtained is apt to be fallacious because the degree of anæsthesia influences the amount of reflex obtained.

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* "La Pupille consideré comme Esthésiomètre." Paris, 1875.

† 'Journal of Physiology,' vol. 2, 443.

‡ SHERRINGTON, 'Journal of Physiology,' vol. 13, p. 730.

§ "On the Sensorimotor Nerve-circuit of Muscles." 'Brain,' 1891, p. 145.

Two examples will make clear the above description.

28.3.1890. *Cat.* 4 lb. 6 oz. Ether and chloroform.

Tracheotomy, carotid exposed. The IIIrd, IVth, Vth, VIth, and VIIth lumbar, and the Ist, IInd, and IIIrd sacral, and Ist and IInd caudal nerve-roots exposed and looped in the spinal canal right and left. The IVth dorsal digital nerve and the musculo-cutaneous exposed on the right foot.

11.16. Carotid connected with manometer. Mean pressure 118 millims. Hg. Both vagus nerves divided in the neck.

11.20. Secondary at 15 centims. Current just perceptible to tongue. Excitation of musculo-cutaneous for 30 seconds. Rise of blood-pressure.

11.23. Secondary at 15 centims. Excitation of IVth dorsal digit for 30 seconds. Rise of blood-pressure, not half the increase obtained from musculo-cutaneous.

11.28. Right IInd caudal root cut in the spinal canal.

11.33–37. Excitation of each nerve as before gave results as before.

11.42. Right Ist caudal root cut.

11.46–51. Excitation of each nerve as before.

11.54. Right IIIrd sacral root cut.

11.58–12.2. Excitation of each nerve gave rise as before.

12.5. Right IInd sacral root cut.

12.8–15. Excitation of each nerve gave rise as before.

12.18. Right Ist sacral root cut.

12.23–30. Excitation of each nerve gave rise as before.

12.33. Right VIIth lumbar root cut.

12.36. Excitation of musculo-cutaneous gave rise as before.

12.38. Excitation of IVth digital evoked no alteration in blood-pressure.

12.40. Repeated—no rise obtained.

12.42. Repeated—no rise obtained.

12.45. Right VIth lumbar root cut.

12.50. Excitation of musculo-cutaneous as before gave now no rise of blood-pressure.
12.55. No rise of blood-pressure from musculo-cutaneous.
12.58. Repeated, with same absence of effect.
1.3–12. Left IVth plantar digital and left musculo-cutaneous exposed as on right side.
1.15. Excitation of each gives rise of blood-pressure. The mean blood-pressure is now 97 millims. Hg.
1.18. Left Vth lumbar root cut in spinal canal.
1.20. Excitation of each nerve gives rise on blood-pressure tracing, but the rise is hardly perceptible from the IVth plantar digital.
1.22. Again, with same result.
1.25. Left VIth lumbar root cut in spinal canal. Blood-pressure falls somewhat. Mean pressure at 1.30 is 93 millims. Hg.
1.32. Excitation of musculo-cutaneous nerve gives no obvious indication of blood-pressure trace.
1.35. Traube-Hering undulations have set in. These are not broken by excitation of either musculo-cutaneous or IVth digital nerve. No indication of the excitation is legible on the trace.
1.45. Traube-Hering undulations and somewhat falling blood-pressure. Excitation of IIIrd and IVth digitals (plantar) and of whole musculo-cutaneous above ankle are without effect.

This example illustrates the difficulty constantly presenting itself in the method. The plantar digitals gave way on the left side before their roots had been interfered with at all, and the result from the musculo-cutaneous was vitiated to an indeterminable extent by the same failure.

In contrast with this stands the first experiment, in which a local muscular contraction was used as index instead of an alteration on the blood-pressure trace.

28.4.1890. *Cat.* Small. Ether and chloroform.

Six roots exposed and looped in the spinal canal right and left, and found by *post-mortem* dissection to be the IInd and Ist sacral and the lowest four lumbar. The Ist and IVth plantar digital nerves exposed on right side.

11.43–45. Thread round IVth digital drawn tight gives slight flexion at ankle. Thread round Ist digital drawn tight gives same movement.
11.48. Lowest root on right side (*i.e.*, IInd sacral) divided.
11.52–54. Threads tightened on IVth and Ist digitals give slight flexion at ankle as before.
11.59. Ist sacral root on right side cut. A thread tightened on each nerve gives the flexion as before.
12.5. VIIth lumbar on right side cut.
12.8. Thread tightened on IVth digital gives no movement at ankle or elsewhere.
12.10. Another thread—also without result.
12.12. Thread tightened on Ist digital gives movement at ankle, but feebler than before.
12.15–20. Currents with secondary at 14 centims. applied to IVth digital give no movement, applied to Ist digital give flexion at ankle stronger than with thread at 11.45.
12.23–30. VIth lumbar root on right side cut. Thread tightened on Ist plantar digital evokes no movement anywhere.
12.33. Currents applied as before give no movement.
12.40–50. Ist and IVth plantar digital nerves exposed on left side. When thread is tightened each evokes flexion at ankle.

12.54. VIth lumbar root on left side cut.

12.58–1.9. Thread tightened on Ist plantar digital evokes a dubious movement at ankle. Thread tightened on IVth plantar elicits flexion at ankle, perhaps, weaker than 10 minutes ago. Repeated with threads a centimetre higher up nerve—same effect as before.

1.12. Weak induced currents (perceptible to tongue) evoke a perceptible flexion at ankle from Ist plantar digital; a fairly good flexion at ankle from IVth digital.

1.20. VIIth lumbar root cut.

1 24–35. No movement elicitable through either of the plantar nerves with secondary at 10 centims.

The experiment showed, therefore, clearly that in this individual the Ist plantar digital nerve was connected with the cord mainly by the VIth lumbar root but also by the VIIth root; and that the IVth plantar digital was connected with the cord mainly by the VIIth lumbar root but also by the VIth lumbar root.

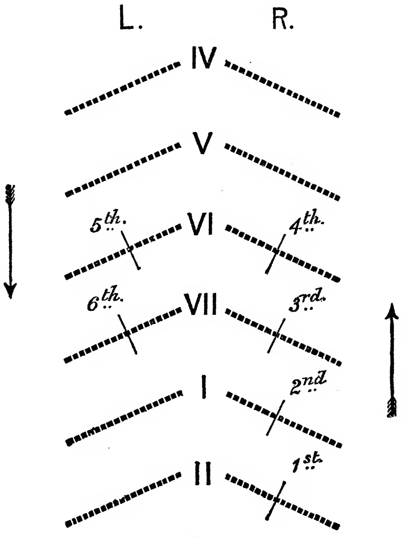
By this method the root-constitution of most of the peripheral nerves of the lower limb was studied; usually in each experiment two small nerves and one large one were taken for analysis.

I will give the experiments in the order in which they were made. From Exp. V. onwards the cord was severed at 6th thoracic segment prior to test of the reflexes.

Experimental Series I. A.

I. *Cat.* Male.

Ist and IVth plantar digital explored, right and left. Movement obtained from each nerve was slight flexion at ankle. 2nd section did not obviously affect either Ist or IVth plantar. 3rd section destroyed IVth plantar, diminished Ist. 4th section destroyed Ist plantar. 5th section diminished Ist plantar very greatly, and IVth plantar dubiously. 6th section destroyed both. Therefore, IVth plantar digital constituted from the VIIth and (?) VIth afferent roots; Ist plantar, from the VIth and VIIth roots.



II. *Cat.* Female.

Ist and IIIrd plantar digitals explored, right and left. Experiment, like I. In Ist plantar digital VIth root > VIIth; but IIIrd digital contains hardly any VIth, almost all VIIth.

III. *Cat.* Female.

Ist and IInd and Vth and VIth collateral digitals (plantar) explored. Sections performed as in I and II.

1st section leaves all nerves unaltered. 2nd section leaves all nerves unaltered. 3rd section reduces reply from Ist and IInd, annuls, or almost so, from Vth digital, and destroys reply from VIth digital. 4th section destroys reply from the remaining digitals under exploration. 5th section (left) reduces the reply from Ist and IInd digitals, and leaves reply from Vth and VIth unaltered. 6th section annuls reply persisting in Vth and VIth digitals.

IV. *Cat.* Female.

IIIrd and IVth and VIIth and VIIIth collateral plantar digitals analysed. Sections as in the previous experiment, except that 1st section was of Ist right sacral; 2nd of VIIth; and 3rd of VIth lumbar; 4th and 5th sections being of VIth and VIIth left lumbar roots respectively.

1st section leaves reply from all the nerves unaltered. 2nd section reduces reply from IIIrd and IVth digitals, destroys the reply from VIIth and VIIIth. 3rd section destroys reply in IIIrd and IVth. 4th section reduces reply from IIIrd and IVth digitals, leaves unaltered the reply from VIIth and VIIIth. 5th section destroys the reply in all.

V. *Cat.* Female.

Ist and IInd plantar collateral digitals, and Ist and IInd and IIIrd dorsal collateral digitals. Sections as in Experiments I–III.

1st section leaves reply from all the nerves unaffected. 2nd section leaves all unaffected. 3rd section leaves reply from IInd plantar less than at first, but the others unaffected. 4th section destroys reply in all, both dorsal and plantar. 5th section destroys reply in Ist dorsal digital, and much reduces reply in all the others, especially IInd dorsal.

VI. *Cat.* Male.

Ist, IInd, IIIrd, IVth, Vth, VIth, VIIth, and VIIIth (α and β) dorsal collaterals. Sections as in Experiment V.

Ist section leaves reply from each unaltered. 2nd section leaves reply from each unaltered. 3rd section destroys reply in VIIIth (both α and β divisions of it) and in VIIth, perhaps also the reply from VIth; reduces the reply from Vth and IVth; leaves reply from IIIrd, IInd, and Ist not obviously affected. 4th section destroys reply in all. 5th section (left) destroys reply in Ist and IInd; reduces reply from IIIrd, IVth, and Vth; leaves not obviously altered the reply from the VIth, VIIth, and VIIIth. 6th section destroys reply from all.

VII. *Cat.* Male.

Repetition of last experiment, except that the 1st section was of Ist right sacral, 2nd of VIIth, and 3rd of VIth lumbar; 4th and 5th sections VIth and VIIth left lumbar roots respectively. Results obtained differ a little from those in Experiment VI. The 4th section diminished but did not annihilate the reply in IInd dorsal digital on left side. The 2nd section destroyed the reply in VIth digital, as well as in VIIth and VIIIth of right side.

VIII. *Cat.* Female.

VIth, VIIth, and VIIIth plantar collateral digitals, and VIth, VIIth, and VIIIth dorsal collateral digitals. Sections as in Experiments I–III.

1st section leaves reply from each nerve unaltered. 2nd section leaves reply from each nerve unaltered. 3rd section destroys reply in all nerves, except perhaps slight reply from VIth dorsal digital. 4th section leaves no trace of reply from VIth dorsal digital. 5th section leaves reply from each nerve unaltered. 6th section annuls VIth and VIIth dorsal. Section of 1st sacral annuls all but VIIIth plantar.

IX. *Cat.* Female.

External and internal plantar nerves behind internal malleolus. Sections as in Experiment I.

1st section leaves reply from each nerve unaltered. 2nd section leaves reply from internal plantar unaltered, but reduces reply from external plantar unmistakably. 3rd section reduces reply from internal plantar, and destroys reply external plantar. 4th section destroys reply from internal plantar. 5th section (left) reduces reply from (left) internal plantar, leaves reply from external plantar unaltered. 6th section reduces reply from external plantar, and nearly, but not entirely, extinguishes reply from internal plantar. 7th section (of Ist sacral root) destroys reply from both plantars.

X. *Cat.* Female.

Both plantars and the musculo-cutaneous nerve. Sections as in Experiment I, except that carried one root further downward on left side.

1st section leaves all nerves unaffected. 2nd section reduces perceptibly the reply from external plantar. 3rd section reduces reply from internal plantar and musculo-cutaneous nerve, and extinguishes reply from external plantar. 4th section extinguishes reply from all the nerves. 5th section reduces reply from internal plantar and musculo-cutaneous; reply from external plantar not obviously affected. 6th section extinguishes reply from musculo-cutaneous nerve, not from external plantar or internal plantar. 7th section extinguishes reply from the last, not quite from external plantar.

XI. *Cat.* Female.

Repetition of X, with same results.

XII. *Cat.* Female.

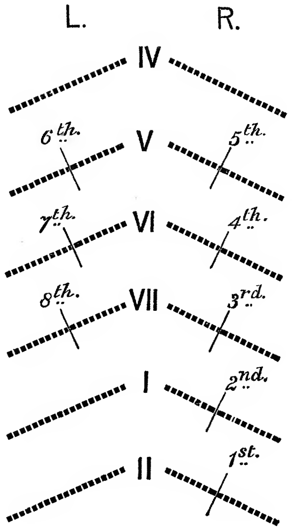
External saphenous nerve on calf, and posterior tibial nerve about 6 centims. above ankle tested. Sections as in Experiment X.

1st section leaves reply from each nerve unaltered. 2nd section leaves reply from posterior tibial nerve not obviously altered, but reduces reply from external saphenous nerve. 3rd section leaves reply from posterior tibial reduced; destroys reply from external saphenous nerve. 4th section extinguishes reply from posterior tibial. 5th section (left) does not obviously affect reply from either nerve. 6th section reduces reply from posterior tibial, much more than reply from external saphenous. 7th section extinguishes the reply from both.

XIII. *Cat.* Female.

Musculo-cutaneous and anterior tibial about 5 centims. below the knee, and the internal saphenous nerve at the knee.

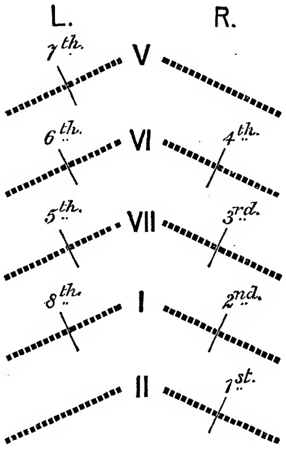
1st section did not alter reply from the nerves. 2nd section did not alter reply from the nerves 3rd section reduced the reply from the musculo-cutaneous and the anterior tibial. 4th section extinguished the reply from the musculo-cutaneous and anterior tibial, and reduced the reply from the internal saphenous nerve. 5th section extinguished the reply from the internal saphenous nerve.



6th section reduced reply from internal saphenous nerve without perceptibly affecting those from the others. 7th section extinguished reply from internal saphenous nerve, and reduced reply from the anterior tibial and musculo-cutaneous. 8th section destroyed the reply from the anterior tibial and the musculo-cutaneous.

XIV. *Cat.* Female.

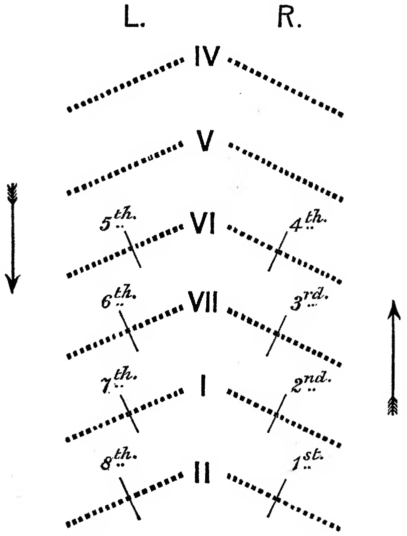
Posterior tibial, external saphenous, and a cutaneous nerve passing from the medial side of the internal popliteal in the thigh to the skin over the outer part of the calf (referred to in note-book for convenience as α).



1st section leaves reply from all three unaltered. 2nd section destroys apparently absolutely the reply from α, much diminishes reply from external saphenous, questionably reduces reply from posterior tibial. 3rd section destroys reply from external saphenous, reduces reply from posterior tibial. 4th section destroys the reply from the posterior tibial. 5th section (left) much reduces reply from external saphenous nerve, leaves reply from posterior tibial, and from α apparently unaltered. 6th section reduces reply from posterior tibial, leaves replies from external saphenous and nerve α apparently unaltered. 7th section produces no further alteration. 8th section (*i.e.*, of Ist left sacral) destroys replies from external saphenous and from nerve α.

XV. *Cat.* Female.

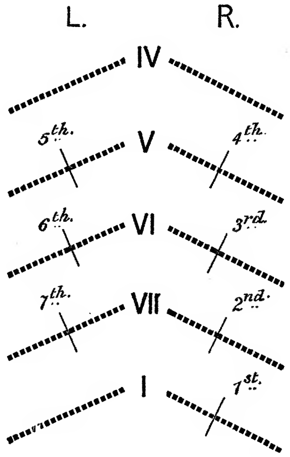
Posterior tibial, external popliteal (behind head of fibula), and a cutaneous nerve arising from the inner side of the sciatic, and passing to skin over the biceps tendon. Sections as in Experiment I, except carried downwards to the IInd sacral on the left side. The cutaneous branch over biceps is designated nerve β.



1st section obviously reduces the reply from nerve β, the rest unaltered. 2nd section destroys reply from β, and obviously reduces reply from posterior tibial. 3rd section obviously reduces reply from external popliteal, and extinguishes the reply from the posterior tibial. 4th section extinguishes reply from external popliteal. 5th section (left) does not obviously affect reply from any of the nerves. 6th section much reduces the reply from the external popliteal and from the posterior tibial; does not affect the reply from nerve β. 7th section extinguishes reply from external popliteal and from posterior tibial, reduces the reply from nerve β. 8th section extinguishes the reply from nerve β.

XVI. *Cat.* Female.

Anterior tibial, musculo-cutaneous, and internal saphenous nerves at the ankle.

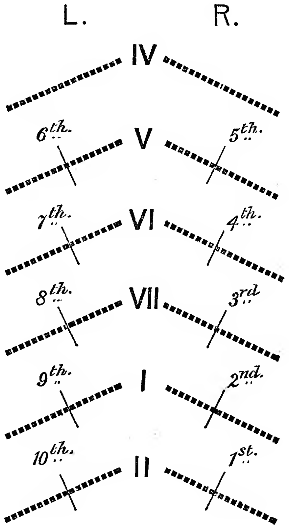


1st section leaves replies from all the nerves unaltered. 2nd section reduces the replies from the musculo-cutaneous and the anterior tibial nerves; does not affect reply from internal saphenous at ankle.

3rd section extinguishes replies from musculo-cutaneous and from anterior tibial, leaves reply from internal saphenous apparently unaltered. 4th section extinguishes reply from all three nerves. 5th section (left) extinguishes reply from internal saphenous nerve at ankle; does not affect replies from anterior tibial and musculo-cutaneous. 6th section diminishes replies from anterior tibial and from musculo-cutaneous. 7th section extinguishes replies from both these nerves. The internal saphenous nerve tested at the top of the thigh gave no reply at the end of this experiment.

XVII. *Cat.* Female.

The internal and external popliteal nerves in the ham, and the internal saphenous in the lower third of the thigh.



1st section does not obviously affect replies from any of the nerves. 2nd section does not obviously affect replies from any of the nerves. 3rd section obviously reduces the reply from each of the popliteal nerves, leaves that from the internal saphenous unaltered. 4th section extinguishes reply from each of the popliteal nerves, and reduces that from the internal saphenous nerve. 5th section extinguishes reply from the internal saphenous nerve. 6th section (left) reduces reply from internal saphenous nerve, leaves replies from the popliteal nerves unaltered. 7th section extinguishes reply from the internal saphenous nerve, does not obviously affect replies from the popliteal nerves. 8th section reduces unmistakably the replies from the popliteal nerves. 9th section extinguishes the reply from the external popliteal, but not that from the internal popliteal. 10th section extinguishes the reply from the internal popliteal. At end of this experiment excitation of central end of the whole sciatic under the gluteus evoked no response, neither did excitation of central end of the obturator on the pectineus muscle.

XVIII. *Cat.* Female.

Internal saphenous nerve at ankle in two branches, an internal (medial) designated *i*, and an external, designated *e*. Anterior tibial on instep in two branches, an inner designated *i'*, an outer designated *e'*. External saphenous nerve about half an inch above the malleolus. Sections as in Experiment XVII.

1st section produces no obvious change. 2nd section causes no alteration in *i* or *e*, nor in *i'* or *e'*, but almost extinguishes external saphenous. 3rd section extinguishes external saphenous, reduces *e'* greatly, *i'* less, does not alter *i* or *e*. 4th section extinguishes *e'* and *i'*, reduces *i* and *e* very greatly. 5th section extinguishes *i* and *e*. 6th section (left) reduces *e* slightly without other change. 7th section extinguishes *i* and *e* without obviously affecting *i'* or *e'* or external saphenous. 8th section extinguishes *i'* and *e'* and questionably reduces external saphenous. 9th section extinguishes external saphenous.

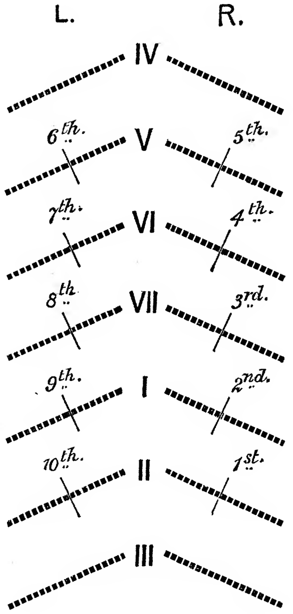
XIX. *Cat.* Female.

Internal saphenous at ankle, then in thigh, rest of anterior crural taken as one trunk in thigh, and obturator on the pectineus muscle. Sections as in Experiment XVI.

1st section produced no obvious change in the reply, which was slight spreading of two innermost toes. 2nd section produced no obvious change. 3rd section almost extinguished the reply from internal saphenous at ankle, but did not quite abolish it. Excitation then applied to the internal saphenous trunk at the lower part of the thigh gave a good reply (slight adduction of thigh). Also good replies of the same character obtained from whole of the anterior crural (except internal saphenous) about 3 centims. below Poupart's ligament, and from the obturator on the pectineus muscle. 4th section extinguished reply from all three nerves, also from the whole anterior crural including the internal saphenous nerve below the groin, also from the obturator nerve in the pelvis. 5th section (left) reduces the reply from the anterior crural and the internal saphenous in the upper third of the thigh very obviously, and also the reply from the obturator nerve on the pectineus. 6th section extinguishes the reply from all three nerves. At the end of this experiment the crural branch of the genito-crural gave a good reply, which was extinguished by section of the IVth root.

XX. *Cat.* Female.

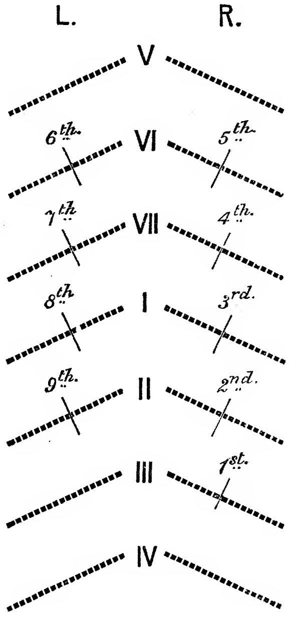
The great sciatic under the gluteus, and the internal saphenous nerve near the knee, in two branches designated *i.s.* and *i.'s.'*; also finally the anterior crural at Poupart's ligament in one trunk.



1st section produced no obvious alteration in the replies (adduction from the internal saphenous nerve, adduction of thigh, and contraction of the anus from the great sciatic). 2nd section produced no obvious alteration in the replies from the internal saphenous, but diminished that from the sciatic trunk; the reply now is not contraction of the anus, but simply adduction of the thigh. 3rd section produced no obvious alteration in the internal saphenous reply, but extinguished the reply from the sciatic altogether. 4th section greatly reduced supply both from *i.s.* and from *i.'s.'*. 5th section abolished reply from *i.s.* and *i.'s.'*; on excitation of the whole anterior crural at Poupart's ligament no reply was obtained. (I then excited the distal end of the efferent root of the left IInd sacral, in order to see if it gave fibres to the plantar muscles, and found it did do so.) 6th section just perceptibly diminished the reply from *i.s.* and *i.'s.'*, but did not obviously affect the reply from the sciatic. 7th section nearly abolished the reply from *i.s.* and *i.'s.'*, but not entirely. 8th section extinguished the replies from *i.s.* and *i.'s.'*, and reduced the reply from the sciatic. 9th section reduced nearly to extinction the reply from the sciatic. 10th section abolished it entirely. On *post-mortem* dissection it was found that in this individual the plexus was extremely "post-fixed." No contribution was discovered from root VI to the lumbo-sacral cord. On the other hand, root VII contributed by small branches to the obturator and anterior crural nerves. The experiment shows that the small filaments from root VII to the anterior crural nerve must have contained afferent fibres; it is to be regretted that, in exciting the sciatic as a whole, the opportunity was lost for determining whether these afferent fibres came from the external or the internal popliteal.

XXI. *Cat.* Male.

At the top of the thigh the sciatic nerve consists of three easily separable divisions, the two popliteals and a nerve which may be referred to as the "hamstring nerve," as it supplies the hamstring muscles. The same arrangement holds in *Macacus* also, as I have pointed out in a previous paper. Where the sciatic nerve emerges from the notch two other nerves lie near it, but posterior to it, both of these latter end in skin in the caudo-gluteal region, and may be designated *p* and *p'* respectively. The replies from *p* and *p'* consist in closure of anus and slight abduction and elevation of root of tail. Hamstring nerve evokes flexion of digits.



1st section produced no effect on the replies. 2nd section reduced replies from *p* and *p'* very much. 3rd section abolished replies from *p* and *p'*, and questionably reduced the reply from the hamstring nerve-trunk. 4th section much diminished the reply from the hamstring nerve. 5th section abolished the reply altogether. 6th section (left) did not detectably affect the replies. 7th section much reduced the reply from the hamstring nerve, but did not obviously affect *p* or *p'*. 8th section abolished reply from the hamstring nerve, and certainly diminished that from *p*, not from *p'*. 9th section abolishes reply from *p* and *p'*.

In the above experiments the sections may appear to have been performed on some nerve-roots without reason, but it must be remembered that it is not easy to recognize during the experiment the exact identity of an individual root exposed in the spinal canal in the region of the cauda equina. The above experiments were made in uncertainty of the exact segmental numbers of the roots which had been divided. This was ascertained in each case by *post-mortem* dissection, in the following manner. The first rib on each side was exposed and the right and left ribs counted, and the number of the lumbar roots was taken from the last rib. In my notebook no attention was paid to the distinction between lumbar and sacral vertebræ, but all the roots below the last thoracic were termed post-thoracic. In quoting the experiments I have considered that the lumbar roots are seven and the sacral three, in the Cat, because those numbers are in use by Mammalian anatomists. In only one of 22 individuals examined was the number of ribs found to be 12 instead of 13, but in one there were 14 ribs instead of 13. Among the individuals used in the above experiments one had a post-fixed plexus in which root VI gave no discovered contribution to the sciatic trunk, but root VII gave a small branch to the obturator nerve, and a smaller twig to the anterior crural—and this was traced by experiment into the internal saphenous nerve. This degree of post-fixture is not common; I have found and figured it in the Monkey (*cf.* "On the Lumbo-Sacral Plexus," 'Journ. of Phys.'), and I have seen other instances in the Cat. The anterior crural and especially the obturator were found by dissection to receive each a branch from the nerve-root lower than the lowest usually entering them, and in one of these individuals I had found by experiment the gracilis muscle supplied with motor fibres from root VII, the last lumbar, although the lowest root usually supplying the gracilis in the Cat is root VI, the lowest lumbar but one. It is thus clear that individual variation occurs in the building of the peripheral trunks from the sensory roots just as it occurs in the building up from the motor roots. Further, the degree of this variation is often sufficiently great to be revealed by naked eye dissection of the roots of the plexus. When one finds by naked eye dissection a plexus of obviously post-fixed or prefixed type the character of its conformation may be impressed not only on its motor composition but on its sensory, and probably on both together, and in the same sense (*cf.* Experiment XX, and also Experiment of January 19, 1891).

The collective results of the foregoing experiments are arranged in the appended table. A large cross denotes that the root in the same horizontal line of the table had a great share in the constitution of the nerve-trunk. A cross in brackets indicates that the root was sometimes represented in the peripheral nerve and sometimes not. Not all the nerves mentioned were *completely* analysed, *e.g.*, the genito-crural was not.

DISTRIBUTION of Afferent Roots in some Nerves of the Lumbo-Sacral Plexus in the Cat, based on Experimental Series I.A.

Number of the nerve-root.		Collateral digital nerves.															
		Plantar.								Dorsal.							
		Ist	IInd	IIIrd	IVth	Vth	VIth	VIIth	VIIIth	Ist	IInd	IIIrd	IVth	Vth	VIth	VIIth	VIIIth
Lumbar	IVth	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
	Vth	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
	VIth	X	+	+	+	+ (?)	..	..	..	+	X	+	+	+	+ (?)	..	..
	VIIth	+	+	+	+	X	+	+	+	(+)	+	+	+	+	X	+	+
Sacral	Ist	..	..	+	+	+	+	+	X	..	..	..	..	..	..	..	(+)
	IInd	..	..	..	..	..	..	..	+ (?)	..	..	..	..	..	..	..	..
Experiments		I, II, III, V. Exp. p. 18	III, V.	II, IV.	I, IV. Exp. p. 18.	III.	III, VIII.	IV, VIII.	IV, VIII.	V, VI, VII.	V, VI, VII.	V, VI, VII.	VI, VII.	VI, VII.	VI, VII, VIII.	VI, VII, VIII.	VI, VII, VIII.

Number of the nerve-root.		Int. plantar.	Ext. plantar.	Ant. tibial.	Musc. cutan.	Thigh Pelvis } obturator.	Thigh Knee Ankle } int. saph.	Post-tibial.	Ext. saph.	Int. popl.	Ext. popl.	Hamstring N.	Cutan. br. *a*.	Cutan. br. *p*.	Cutan. br. *p'*.	Gen. crur. (crural).
Lumbar	IVth	..	..	..	..	..	..	..	..	..	..	..	..	..	..	+
	Vth	..	..	..	..	+ +	+ + +									
	VIth	+	..	+	+	+ +	+ + +	+	..	+	+	+				
	VIIth	+	+	+	+	..	(+)	+	+	+	+	+				
Sacral	Ist	(+)	+	..	..	..	..	+	X	+	+	+	+	+	+	
	IInd	..	(+)	..	..	..	..	..	..	+	..	..	..	+	+	
Experiments		IX, X, XI.	IX, X, XI.	XIII, XVI, XVIII.	X, XI, XIII, XVI.	XIX.	XIII, XVI, XVII. XVIII, XIX, XX.	XII, XIV, XV.	XII, XIV, XVIII.	XVII, XXI.	XV, XVII, XXI.	XXI.	XV, XX.		XV, XX.	XIX.

X denotes that the root has a predominant share in the nerve-trunk.

(+) denotes that slight but distinct evidence of the root was *sometimes* found.

+ (?) denotes that the evidence obtained was never better than dubious.

A certain number of experiments were made on the Monkey by exactly the same method as those above related in the Cat. The species of Monkey employed was, without exception, *Macacus rhesus*, and, for the most part, immature individuals, *e.g.*, in the females menstruation had hardly commenced. In regard to *Macacus rhesus*, it will be remembered that the lumbar vertebræ are seven as in the Cat, and that the sacral vertebræ are three, but that there are twelve pairs of ribs instead of thirteen as in the Cat. As stated in my paper on the efferent fibres of the lumbo-sacral plexus, the correspondence between the roots of that region in Cat and Monkey, respectively, seems as follows :—

Cat.		*Macacus rhesus.*
IInd lumbar root (? + Ist)	=	Ist lumbar.
IIIrd ,,	=	IInd ,,
IVth ,,	=	IIIrd ,,
Vth ,,	=	IVth ,,
VIth ,,	=	Vth ,,
VIIth ,,	=	VIth ,,
Ist sacral root	=	VIIth ,,
IInd ,,	=	Ist sacral.
IIIrd ,,	=	IInd ,,

Further, it must be noted that the foot of *Macacus* has five well developed digits instead of the four of the hind foot of the Cat; I have, therefore, attempted the analysis of twenty instead of sixteen collateral digital nerves.

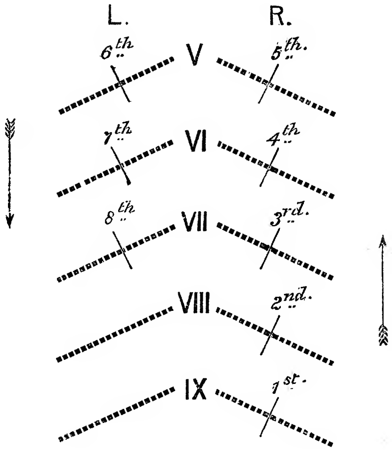
The segmental number of the individual root could only be positively ascertained by *post-mortem* dissection. As with the Cat, the numbering of the roots was always commenced from the first, not from the last rib, and the counting was carried out on both sides.

Experimental Series I. B.

1. *M. rhesus.* Young Female.

Ist, IInd, and IIIrd, and VIIIth, IXth, and Xth dorsal collateral digital nerves analysed for root composition. The reply obtained from each was flexion with adduction of the hallux, occasionally accompanied by slight flexion of other digits as well.

1st section produced no obvious alteration in the reflex replies. 2nd section produced no obvious alteration in the replies. 3rd section cut down the replies from Xth and IXth digitals, the former almost to extinction, but did not affect the other replies at all. 4th section destroyed reply from Xth, IXth, and VIIIth, and reduced replies from IIIrd, IInd, and Ist, the last very slightly; the character of the reply when obtained was now a slight flexion at the ankle. 5th section destroyed the reply in all. 6th section (left) much reduced the reply in the Ist digital obviously, in the IInd slightly, hardly at all in



IIIrd, the three degrees of reduction were a striking series; left the other replies unaffected. 7th section destroyed the replies from I, II, and III, and reduced the replies from the external three, nearly, but not quite abolishing reply from VIIIth. 8th section abolished all reply.

I. *M. rhesus*. Female.

The most internal five collateral dorsal digitals and the VIIIth, IXth, and Xth analysed. Sections as in previous experiment.

3rd section reduced reply from Xth; no other effect. 4th section reduced reply from IIIrd, IVth, and Vth, and abolished reply from Xth, IXth, and VIIIth. 5th section abolished reply from all. 6th section (left) diminished the reply from Ist; no other effect detected. 7th section destroyed reply from the five internal digitals and from the VIIIth; reduced the replies from the other two. 8th section extinguished all the replies.

III. *M. rhesus*. Female.

All the dorsal collateral digits (but the IXth was accidentally injured early in the experiment on the right side). Sections as in previous experiment.

2nd section produced no obvious effect. 3rd section greatly reduced the reply from the Xth, the IXth was in an unsatisfactory condition. The section did not obviously affect any of the other replies. 4th section extinguished the reply in all except the Ist and IInd, and reduced it from both of them. 5th section extinguished all reply. 6th section (left) reduced the reply in the Ist, IInd, IIIrd, and apparently in the IVth, but certainly not in the rest. 7th section extinguished the reply in the Ist, IInd, IIIrd, IVth, Vth, and VIth, and reduced it in the rest, but much less in the Xth and IXth than in the VIth. 8th section abolished all replies.

IV. *M. rhesus*. Female; older than the preceding specimens.

All the plantar digital (collaterals) explored. Sections as in previous experiment.

1st section produced no obvious change in any of the replies. (The replies were in the case of each nerve the same flexion of hallux, with adduction and occasional flexion of 2nd digit seen in Experiments I–III; a slight difference appeared to be, that, in this experiment, contraction and protrusion of the anus occurred with the movement of the hallux sometimes.) 2nd section produced no obvious change in any of the replies. 3rd section appeared to extinguish the reply from the Xth collateral digital, and to diminish the reply from all the others except the Ist. A scale of less and less reduction by the section was most obvious, as the replies were reviewed in series passing from the outer to the inner border of the sole, although the nerves had taken some time to prepare and must have suffered in isolating from the surrounding adipose tissue. 4th section destroyed the reply from the VIth and VIIth, the VIIIth and IXth, and in the Xth digitals, and diminished it from all the rest, but much more from the Vth than from the Ist. 5th section abolished the reply from all. 6th section (left) greatly reduced but did not abolish reply from the Ist, and reduced the reply from the IInd, IIIrd, and IVth, (?) Vth digital. 7th section abolished replies from the Ist, IInd, and IIIrd digitals, but not from the rest; although appeared to reduce all of them, epecially IVth and Vth, and the Xth and IXth least. 8th section completely abolished replies from all.

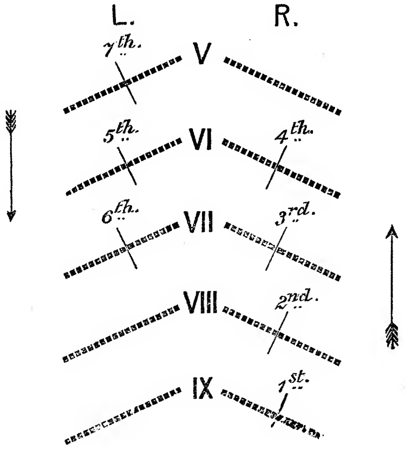
V. *M. rhesus.* Female; young.

The dorsal collateral digitals, I–V inclusive, and the plantar collateral digitals I–V inclusive. The external saphenous about 2 centims. above the external malleolus in two branches, an anterior (*a*), and a posterior (*p*). Sections as in preceding experiment.

1st section did not obviously affect the replies. 2nd section reduced the reply from the external saphenous, *p*. 3rd section reduced the supply from both branches of the external saphenous, and from the Vth, IVth, and (?) IIIrd plantar digitals, but did not obviously affect the reply from any of the dorsal digitals under analysis. 4th section extinguished the reply from the external saphenous, both branches, and from its trunk 2 inches above the external malleolus, and from the Vth, IVth, and IIIrd plantar digitals, and reduced reply from Vth dorsal digital considerably, to less extent from IVth dorsal digital. 5th section extinguished reply from all the digitals, dorsal and plantar. 6th section (left) reduced the reply from all the dorsal digitals under examination except the Vth, and from the Ist and IInd plantar digitals, did not produce any change in the rest, nor in external saphenous. 7th section extinguished reply from all the dorsal digitals, from the Ist and IInd plantar digitals, obviously diminishing it in the other plantar digitals and in the external saphenous, both divisions. 8th section extinguished the reply from the plantar digitals under examination, and nearly extinguished reply from external saphenous *p* but not quite *a*. 9th section was therefore made of the VIIIth post-thoracic root, and this extinguished reply from external saphenous *p*.

VI. *M. rhesus.* Female; young.

The five most external dorsal and plantar collateral digital nerves.



2nd section produced no obvious change in the replies. 3rd section reduced greatly the Xth, IXth, VIIIth, and VIIth plantar, and from the Xth and IXth dorsal digitals, to less extent the reply from the VIIIth dorsal and from the VIth plantar; no other change obvious. 4th section destroyed reply in all the plantar and dorsal digitals examined. 5th section (left) reduced the reply in the VIth, VIIth, and VIIIth dorsal collaterals, also in the VIth plantar. 6th section destroyed the replies from all the dorsal and plantar collaterals under analysis, except the VIth dorsal; this was tested many times over, and appeared to give an indubitable reflex (viz., slight flexion of ankle with some eversion of foot). 7th section was then performed on Vth lumbar root, the movement disappeared at once.

VII. *M. rhesus.* Female; young.

The seven most external plantar collaterals, and the external saphenous nerve above the ankle (about 3 inches above it). Sections performed as in Experiment V.

2nd section produced no obvious change. 3rd section diminished reply from Xth and IXth digitals, and very obviously from external saphenous. 4th section abolished reply from all the digitals under analysis except the Vth and IVth, the reply obtainable from IVth being much better than from Vth (flexion of ankle in each case); reply from external saphenous also completely abolished. 5th section abolished reply from the remaining two digitals. 6th section (left) diminishes reply from none of the nerves examined. 7th section diminishes reply from all the nerves examined; abolishing reply from the IVth digital, or nearly abolishing it. 8th section destroys the reply in all the digital nerves, but not in the external saphenous. 9th section destroys the reply in the external saphenous nerve.

VIII. *M. rhesus.* Female; young.

Five considerable branches of the external cutaneous in the upper half of the thigh, the internal saphenous nerve at the ankle, and the Ist, IInd, IIIrd, IVth, and Vth dorsal collateral digitals analysed. The internal saphenous taken in two twigs. Sections as in Experiment X. The branches of the external cutaneous are taken from without inwards α, β, γ, δ, ε.

1st section, 2nd section, and 3rd section produced no obvious change in any of the replies. 4th section extinguished the reply in the Vth and IVth digitals; very nearly extinguished it in the IIIrd digital; reduced it considerably in the IInd digital; and reduced it less in the Ist digital. Did not affect at all the reply from the saphenous twigs, nor from the external cutaneous divisions. 5th section extinguished the reply from each of the two saphenous twigs; certainly diminished somewhat the reply from external cutaneous β, probably from α and γ also; extinguished the reply from each of the digitals under analysis. 6th section greatly reduced reply from each of the divisions of the external cutaneous, but less ε and δ than from the others. 7th section abolished reply from all. 8th section affected the reply from five or six branches of the external cutaneous α, β, γ, δ, ε, ζ, examined on the opposite thigh to correspond with those examined in right thigh; α and β were affected less than the rest. A nerve found more external and nearer the anterior superior spine was not affected at all, and was found afterwards not to belong to the external cutaneous trunk. 9th section abolished replies from α, β, γ, δ, ε, ζ; reduced replies from γ almost to extinction but not quite. Did not affect any of the other replies detectably. 10th section abolished replies from twigs of internal saphenous at ankle; from external cutaneous γ (ζ was not tried because it had become damaged); diminished the replies from the Ist and IInd digitals; but not obviously from the IIIrd. 11th section abolished replies from all the digital nerves under examination. *Post-mortem* dissection showed the plexus in this individual to be of markedly post-fixed type; but I found no branch from root VI to the anterior crural or to the obturator.

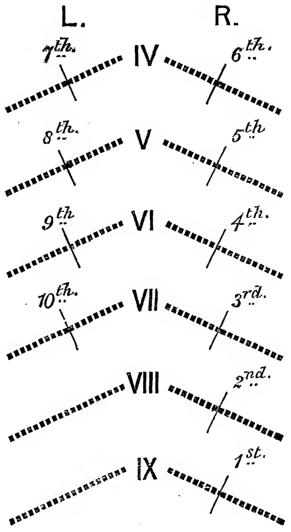
IX. *M. rhesus.* Female; young.

External plantar, internal plantar, posterior tibial, and musculo-cutaneous nerve at ankle. Sections as in Experiment I. The reply consisted in extension at the ankle.

2nd section produced no obvious alteration in reply. 3rd section diminished the reply from the external plantar, and from the musculo-cutaneous. 4th section diminished reply in both plantar nerves, in the anterior tibial, and in the musculo-cutaneous. Before this section was made the anterior tibial at the ankle had been followed into its two divisions, external and internal, and a reply had been obtained from each; the 4th section destroyed the reply from the outer division, but not wholly from the internal. 5th section abolished the reply from all the nerves. The reply from the internal plantar before the 5th section had been very much greater than that from the external plantar, which responded quite feebly. After the 5th section the whole posterior tibial, about 2 inches above the ankle, was tested and gave no sign of reflex. 6th section (left) diminished reply in internal plantar and in musculo-cutaneous nerve. 7th section further diminished replies from internal plantar and from musculo-cutaneous; also from anterior tibial, and from external plantar. 8th section extinguished replies from all, as also from the posterior tibial about 5 centims. above the ankle.

X. *M. rhesus.* Female; older.

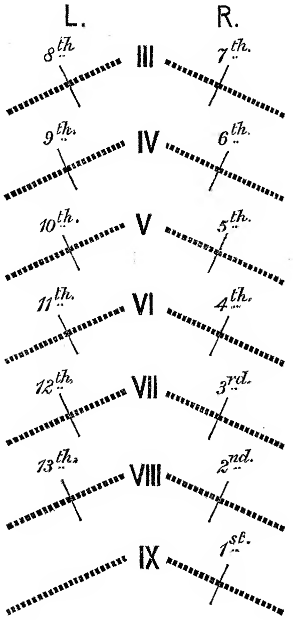
Internal saphenous nerve at ankle, branch from musculo-cutaneous to external plantar branch, the external plantar, the deep branch of the external plantar, cutaneous branch from the sciatic running over the head of the fibula. Sections as in diagram.



2nd section produced no obvious effect. 3rd section reduced almost to extinction the reply from connecting branch between musculo-cutaneous and external plantar; also much reduced reply from deep plantar and from cutaneous branch over head of fibula; did not affect other replies. 4th section extinguished replies from connecting branch between musculo-cutaneous and external plantar, also reply from deep branch of external plantar and from cutaneous branch over head of fibula. Did not apparently affect reply from internal saphenous nerve at ankle. 5th section abolished reply from internal saphenous nerve at ankle. This was tried several times at various intervals; on following the internal saphenous to about 8 centims. above ankle a reply was obtained. 6th section cut out this reply also. The reply from internal saphenous was a movement in the adductor group of the thigh, including in that group the gracilis, but as to whether the gracilis alone, or with other muscles, contracted, I failed to assure myself. On some occasions it seemed the gracilis alone. 7th section (left) did not obviously affect reply from internal saphenous at ankle, nor the other replies (flexion of hallux). 8th section abolished the reply from the internal saphenous nerve at ankle, but did not obviously affect the other replies. 9th section diminished the replies from the deep plantar, and perhaps slightly from the connecting branch, and certainly from the cutaneous passing over the head of the fibula. 10th section abolished reply in the connecting branch, and in cutaneous nerve running by the head of the fibula. The deep plantar nerve was now found to have got damaged, and no further test of it was employed, but the whole external plantar was tested close above the heel, and found to there yield no reply.

XI. *M. rhesus.* Female; young.

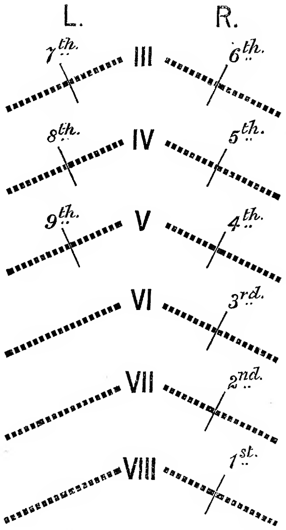
External cutaneous nerve at top of thigh, in divisions, α, β, γ, δ: α the most external, δ the most internal. Internal saphenous nerve at knee, external popliteal and internal popliteal nerves in the ham. Sections as in diagram.



1st section produced no obvious effect. 2nd section produced no obvious effect. 3rd section seemed to diminish reply from internal popliteal. 4th section diminished reply from both popliteals, and (?) from internal saphenous nerve at knee. 5th section decidedly diminished reply from internal saphenous nerve at knee, destroyed reply from internal popliteal certainly, questionably from external popliteal also (both examined in the ham, but not higher). Replies from divisions α, β, γ, δ of the external cutaneous still quite unaffected; these replies consisted in movement at upper and inner part of thigh. 6th section abolished reply in all the nerves except the external cutaneous, and in that diminished the reply about equally in each of its three divisions examined. 7th section abolished replies from each of the divisions of the external cutaneous. 8th section (left) diminished the reply from each of the divisions of the external cutaneous, α, β, γ, δ (these divisions each corresponded, I think exactly, certainly approximately, to the divisions examined on the right side). 9th section abolished the reply from the external cutaneous, α, γ, δ, but not completely in β. It diminished very obviously the reply from the internal saphenous at the knee, but did not affect in a detectable manner the replies from either popliteal. 10th section abolished the reply from external cutaneous, β, and from a small side branch of the internal saphenous close above the knee-joint, but certainly did not abolish completely the reply from the whole trunk at the knee. The reply from each popliteal was still not obviously impaired. 11th section abolished the faint reply from internal saphenous, greatly reduced reply from external popliteal, considerably reduced reply from internal popliteal. 12th section extinguished the reply from the external popliteal in the ham, but left over a fairly good reply from the internal popliteal trunk in the ham. This reply was destroyed by a 13th section through the VIIIth left sub-thoracic root. The reply consisted in contraction of the hamstring muscles, especially those of the outer set. This plexus was found on *post-mortem* dissection to be remarkably "post-fixed." I did not discover by dissection any branch from the Vth root to the external cutaneous nerve, but if, as not infrequently happens, the external cutaneous receives thread-like accessions at a long distance from the vertebral column, and those threads lie imbedded in the psoas, it is possible that such an accession was present and was missed in the dissection.

XII. *M. rhesus.* Male; young; testicles descended.

Internal saphenous nerve about 3 inches below POUPART'S ligament; the obturator nerve in two divisions outside the pelvis, the one on the pectineus being α, the deeper β; the internal cutaneous nerve below the knee. Sections performed as in the diagram. The reflex reply from the internal saphenous is in the extensor quadriceps cruris; that from the internal cutaneous also there, but more to the inner side of the muscle; that from the obturator is in the psoas, and the quadriceps extensor about its middle third.

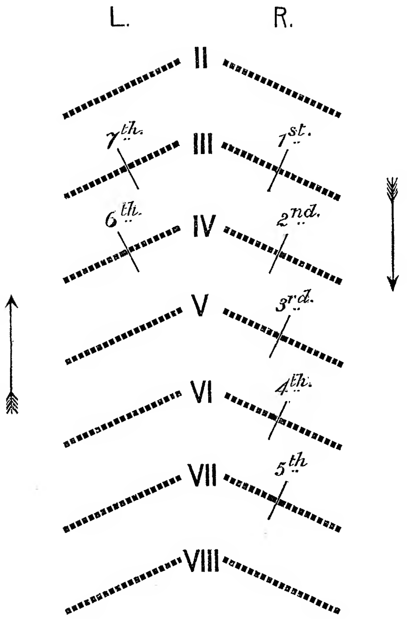


1st section did not change the reply obviously. 2nd section did not obviously affect the reply. 3rd section did not obviously affect the reply. 4th section much diminished the reply from the branch of the internal cutaneous, decidedly also the reply from the obturator β, not obviously the other replies. 5th section diminished the reply from the internal saphenous, destroyed the reply from the internal cutaneous, diminished almost to extinction the reply from the obturator, both α and β. 6th section destroyed the reply from the internal saphenous, and finished the abolition of the replies from the obturator divisions. 7th section (left) diminished the reply from the internal saphenous, but had no obvious effect upon the other replies. 8th section diminished further the reply from the internal saphenous, and diminished obviously the replies from both obturator divisions and from the internal cutaneous branch below the knee. 9th section abolished all the replies. The crural twig of the genital crural gave a slight reflex retraction of the testicle at the end of this experiment.

XIII. *M. rhesus.* Male.

External cutaneous (two branches of) at the upper part of the thigh; the anterior tibial nerve in two branches near its origin from the peroneal; the musculo-cutaneous low down above the ankle; the obturator as three branches in the thigh. Sections performed as in diagram.

1st section diminishes the reply from the external cutaneous, both branches; does not affect the other replies. 2nd section abolishes the reply from the outer of the two branches of the external cutaneous, but not completely from the inner. 3rd section abolishes the replies from all three branches of the obturator, does not affect the other replies at all. 4th section greatly reduces the reply from the ante-



rior tibial nerve, and obviously diminishes reply from the musculo-cutaneous. 5th section abolishes the reply from the anterior tibial and from the musculo-cutaneous, but the reply from the external cutaneous still remains distinct (from the inner branch of the pair tested). 6th section (right, IVth lumbar) reduces reply from obturator obviously. 7th section nearly destroys the reply from the external cutaneous (right side), but not completely.

XIV. *M. rhesus.* Female; young.

Internal cutaneous nerve in thigh examined in four divisions—α, β, γ, δ. Branch of internal saphenous given off from trunk about 5 centims. above the knee. The whole obturator nerve just outside the pelvis. ? The middle cutaneous branch of the anterior crural. Of the divisions of the internal cutaneous, the most external is α, the most internal δ. Sections performed just as in the last experiment.

1st section, no effect. 2nd section, no change detected. 3rd section, no effect detected. 4th section diminished the reply from the internal cutaneous branches, especially β, γ, and δ, from the branch of the middle cutaneous, but to less extent. Considerable diminution in the reply from the obturator nerve. No obvious diminution in the side branch from the internal saphenous nerve, nor perhaps in the middle cutaneous nerve. 5th section abolished the replies from all the divisions of the internal cutaneous, not quite from the middle cutaneous, but quite from the side branch of the internal saphenous, and completely from the whole obturator trunk. It was well seen in this experiment that the 4th section reduced the reply from the obturator more than did the 5th section. 6th section abolished the reply from the ? middle cutaneous. 7th section (left) produced no obvious effect on the trunks under analysis. 8th section abolished reply from a side branch of the internal saphenous above the knee, and greatly reduced the reply from all the branches of the internal cutaneous, α, β, γ, δ. (I am not sure that these accurately corresponded with those taken on the right side, but γ probably did quite accurately.) A questionable reduction in the amount of reply from the obturator trunk. No middle cutaneous found. Of the divisions of the internal cutaneous, it was not clear that α, the most external, did not suffer by the 7th section; the 8th section almost abolished reply from it. 9th section abolished the replies from all the nerves examined, except from the obturator trunk, from which a distinct reply was still elicitable. 10th section abolished all reply. On *post-mortem* dissection, the plexus was found markedly postfixed, nearly as much so as in the individual of Experiment X.

XV. *M. rhesus.* Female; young.

The hamstring nerve in two divisions α (outer), β (inner); the crural branch and the genital branch of the genito-crural; the internal cutaneous, in three divisions, close below POUPART's ligament. Sections as in Experiment XI.

1st section, no obvious change in the replies. 2nd section, no obvious change in the replies, except a diminution in the reply from each division of the hamstring nerve. The reply from each division of the hamstring nerve is a slight flexion of ankle, and flexion of hallux. 3rd section, the reply from the hamstring nerve is abolished in both parts; the replies from the other trunks not obviously altered. 4th section, the reply from the genito-crural divisions is not obviously altered; that from internal cutaneous is lowered in all three divisions. 5th section, the reply from the genito-crural divisions is unaltered; that from internal cutaneous is destroyed in each division. 6th section, the reply from the crural branch of the genito-crural, contraction of psoas is diminished but not abolished; the reply from the genital branch seems to be abolished. 7th section (left), the reply from the crural branch of the genito-crural is nearly, but not quite, abolished. 8th section, the reply from the internal cutaneous is much diminished, except in the middle of the three divisions. 9th section, the reply from the internal cutaneous is abolished. 10th section (of the VIth lumbar root), the replies from the two divisions of the hamstring nerve which were isolated are now diminished, but had not been so by the earlier section. 11th section (of the VIIth lumbar root) seems to extinguish the replies from the hamstring divisions, both of α and β, altogether.

XVI. *M. rhesus.* Female; young.

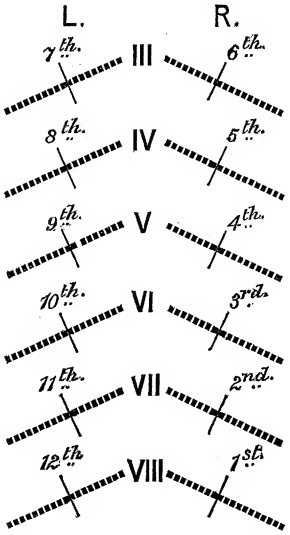
Two long cutaneous nerves passing over the back of the fibula; the branch of the hamstring nerve to the inner hamstrings, and two to the outer hamstrings. The internal and external popliteal nerves below the gluteal region. Sections performed as in Experiment I.

2nd section produced no obvious change. 3rd section diminished replies from all the nerves, especially from the three branches of the hamstring nerve. 4th section abolished replies from the branches of the hamstring nerve, from the cutaneous fibular branches, and almost from the internal popliteal, though not from the external popliteal. 5th section abolished all the replies. 6th section (left) produced no obvious change. 7th section diminished very greatly the replies from the two cutaneous fibular branches, and diminished the replies from the branches, external and internal, of the hamstring division of the sciatic nerve, also detectably from the external popliteal. 8th section abolished all replies from the two cutaneous nerves, also apparently from the hamstring nerve, also from the external popliteal trunk, but not from the internal popliteal. 9th section abolished reply from the internal popliteal trunk (9th section was of VIIIth left-hand sub-thoracic root).

XVII. *M. rhesus.* Female; young.

Branch toward skin passing head of fibula, the external saphenous below the ham not far from its origin, the internal saphenous just above the internal malleolus. A cutaneous branch from the anterior crural, apparently corresponding with the middle cutaneous of Man, taken in four small branches, α, β, γ, δ, in the upper part of the thigh.

1st section certainly diminished reply from external saphenous. 2nd section abolished reply from external saphenous, weakened that from cutaneous branch near the biceps tendon, did not affect the other replies. 3rd section abolished reply from the nerve near the biceps, did not affect replies from branch of anterior crural, nor from internal saphenous. 4th section did not abolish reply from internal saphenous near the ankle, but reduced it very greatly; reduced very much reply from middle cutaneous in all its four branches. 5th section abolished reply from internal saphenous, and from all of ? middle



cutaneous except branch β (the most internal one). 6th section abolished that reply also—a slight contraction in the region of the pectineus and adductor longus. 7th section (left) produced no obvious effect on the replies from any of nerves (the branches of the ? middle cutaneous examined on this side were three in number and certainly did not exactly correspond with those used on the right side). 8th section diminished distinctly the reply from each of the three branches of the middle cutaneous, but not that from internal saphenous at internal malleolus. 9th section abolished the replies from the ? middle cutaneous (each of its branches) and from the internal saphenous; no effect on other replies. 10th section reduced reply from nerve near biceps, but reply from external saphenous remained unaltered. 11th section much reduced reply from external saphenous, and abolished reply from nerve near biceps tendon. 12th section abolished all reply. The condition of the animal was not good, the extremities having become very cold, but a subcutaneous nerve twig near the anterior superior spine gave a good reply, as in Experiment VIII, so that in each case the nerve must have been connected with a root above the IIIrd lumbar.

The collective results of the foregoing series of experiments are for the sake of clearness of comparison placed in a tabular form, as were the results obtained on the Cat. Each large cross denotes that the spinal root it lies opposite contributed largely to the nerve. Crosses in brackets mean that the root did not appear to contribute to the nerve-trunk in all individuals, but did in some.

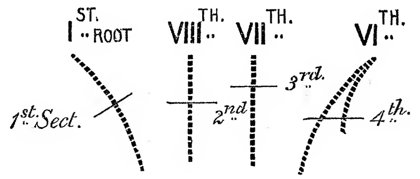
DISTRIBUTION of the Fibres of the Afferent Roots in some Nerve-trunks of the Lumbo-sacral Plexus of *Macacus rhesus*, based on Experimental Series I. B.

Number of the nerve-root.	Collateral digital nerves.																				Int. plantar.	Ext. plantar.	Anter. tibial.	Musc. cutan.	obturator.		int. saph.			Post. tib.	Ext. saph.	Int. popl.	Ext. popl.	Hamstring N.	Ext. plantar (deep).	Ext. br. of ant. tib. N. on the ankle.	Cutan. br. from ext. popl. over head of fibula.	Br. from ext. saph. to ext. plantar.	ext. cutaneous.		genito-crural.		int. cutaneous.	
	Dorsal.										Plantar.																																	
	Ist	IInd	IIIrd	IVth	Vth	VIth	VIIth	VIIIth	IXth	Xth	Ist	IInd	IIIrd	IVth	Vth	VIth	VIIth	VIIIth	IXth	Xth					Thigh	Pelvis	Thigh	Knee	Ankle										Above patella	Below patella	Crural	Genital	Above knee	Below knee
Lumbar IIIrd	...	...	...	...	...	...	...	...	...	...		...	...	...	...	...	...	...	...	...	...	...	...	...	(+)	(+)	+			...	...	...	...	...	...	...	...	...	+		+	+		
Lumbar IVth	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	+	+	X	X	(+)	...	...	...	...	...	...	...	...	...	+	+	...		X	+
Lumbar Vth	X	X	X	X	+	+	...	...	...	...	X	X	+	+	+	...	...	...	...	...	+	(+?)	+	+	+	+	+	+	+	+	...	+	+	...	...	...	...	...	...		...		+	X
Lumbar VIth	+	+	X	X	X	X	X	X	+	+	X	X	X	X	X	X	+	+	+	+	+	+	+	+	(+)	(+)	...			+	+	+	+	...	+	+	+							
Lumbar VIIth	...	...	...	...	...	...	(+)	+	+	+	...	(+)	+	+	X	X	X	X	X	X	+	+	...	+	...		...			+	+	+	+	+	...	...	+	+						
Sacral Ist	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...		...			+	+	+												
Sacral IInd																																												
Experiments.	I, II, III, V, VIII.	I, II, III, V, VIII.	I, II, III, V, VIII.	II, III, V, VIII.	II, III, V, VIII.	III, VI.	III, VI.	I, II, III, VI.	I, II, VI.	I, II, III, VI.	IV, V.	IV, V.	IV, V.	IV, V, VII.	IV, V, VII.	IV, VI, VII.	IV, VI, VII.	IV, VI, VII.	IV, VI, VII.	IV, VI, VII.	IX.	IX, X.	XIII.	IX, XIII.	XII, XIII, XIV.		VIII, X, XII, XVII.			IX.	V, VII, XVII.	XI, XVI.	XI, XVI.	XV, XVI.	X.	XIII.	X, XVI, XVII.	X.	VIII, XI, XIII.		XV.		XII, XIV, XV.	

For the sake of comparison with the arrangement found in the hind limb, a certain number of experiments were made upon the nerves of the fore limb in the Cat by the same method as that employed upon the hind-limb, with one difference. I was not aware at the time with what little risk of hæmorrhage section of the posterior roots of the brachial spinal nerves can be performed inside the vertebral canal. I therefore, instead of performing the sections in the vertebral canal as had been done in the experiments on the pelvic limb, divided in the case of the brachial nerves, the entire nerves outside the vertebral canal, as did PEYER, KRAUSE, and TÜRCK in their experiments. The sources of fallacy attaching to this method I have already mentioned, but the results are given here because so completely harmonizing with the results on the lower limb. The operation presents no difficulty, the chief point being that the upper surface of the 1st rib must be carefully exposed to view in a good light.

Experimental Series I. C.

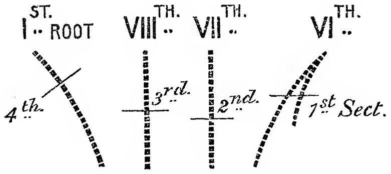
Experiment I. *Cat.* Female. 27.6.1890.



Six digital nerves examined on the dorsum of the right fore foot. Also later, the ulnar trunk and the radial trunk, each 3 centims. above the wrist. Later the posterior interosseous trunk near its origin.

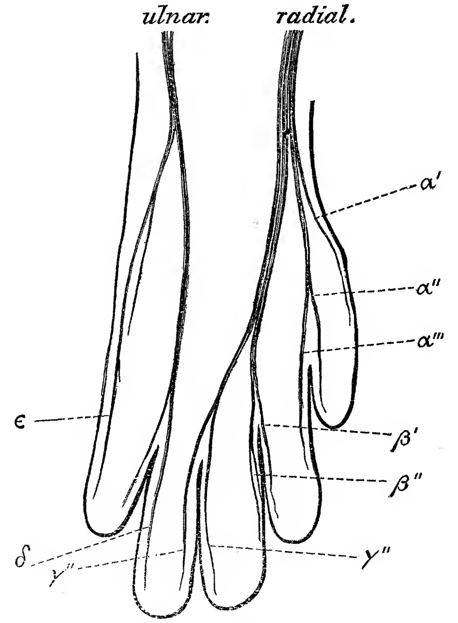
1st section, reply remains in all the dorsal digitals. 2nd section, destroyed reply from the VIth and VIIth dorsal digitals, both from the ulnar trunk. Also destroyed reply in ulnar trunk above wrist. 3rd section destroyed reply from all the digitals under examination; also from the radial trunk above the wrist, but not from a cutaneous branch near, which was afterwards traced up to lie beside the musculo-spinal trunk about the elbow, but not traced further. Also 3rd section destroyed reply from the posterior interosseous. 4th section destroyed reply from the cutaneous nerve above-mentioned.

Experiment II. *Cat.* Female. 30.6.1890.



Nerves on dorsum of hand.

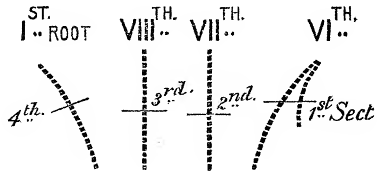
The nine small branches analysed under nomenclature in figure.



Dorsum of fore-foot.

1st section, no effect upon any of the replies detected. 2nd section, abolished replies from α', α'' α''' lessened obviously from β'. 3rd section, abolished the replies from β' and β''; diminished replies from γ'. 4th section, abolished the replies from all the remaining digitals under examination.

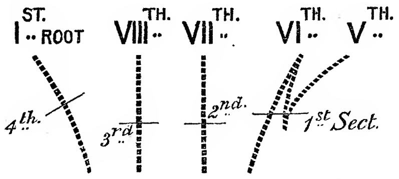
Experiment III.—*Cat.* Female. 1.7.1890.



Analysis of dorsum of hand and forearm.

1st section abolished reply from a large cutaneous nerve passing down the radial edge of the forearm and derived from below the biceps close above bend of elbow, but left reply from the seven dorsal digitals under analysis unaltered. 2nd section abolished reply from the three outermost dorsal collaterals of the radial trunk. 3rd section reduced the reply from the two outermost of the ulnar dorsal collaterals considerably. 4th section abolished reply from all the digital nerves under examination. A smart reply was obtained from the posterior interosseous near its origin until the 3rd section was made.

Experiment.—*Cat.* Male. 2.7.1890.

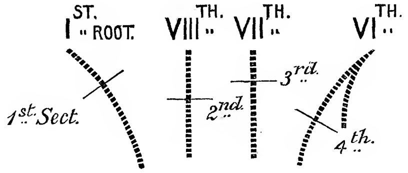


Analysis of nerves of palm.

Ist plantar collateral = α, IIIrd ditto = β, IVth ditto = γ, Vth ditto = δ, VIth ditto = η, VIIth ditto = ζ, VIIIth ditto = ϵ, IXth ditto = θ, Xth ditto = κ, IIIrd dorsal collateral = β'.

1st section abolished reply from none, nor obviously diminished reply, except from α, β, β'. 2nd section abolished reply from α, β, β', γ, δ, and greatly reduced the reply from η, and obviously reduced it from ζ. 3rd section abolished reply from the remaining digitals under analysis.

Experiment IV.—*Cat.* Female. 3.7.1890.

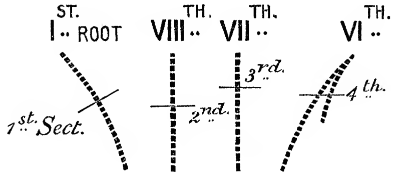


Nerves of the right palm.

The IIIrd palmar collateral = α, IVth ditto = β, Vth ditto = γ, VIth ditto = δ, VIIth ditto = η VIIIth ditto = ζ, Xth ditto = ϵ.

1st section reduced the reply obviously from ϵ, not obviously from ζ. 2nd section abolished reply ϵ and ζ, reduced it greatly from η. 3rd section abolished reply from all the digital nerves under examination. The trunk of the radial, 3 centims. above the wrist, was now examined in two natural divisions, a larger, κ, and a smaller, λ, containing the nerves to the pollex and anterior side of index. No reply was obtainable from κ, a good reply from λ, and also from a twig of the external cutaneous nerve near. Section of the part of the VIth root shown in diagram abolished replies from λ and from external cutaneous at point examined.

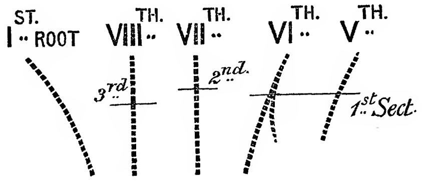
Experiment V.—*Cat.* Female, young. 5.7.1890.



The branches of the musculo-spiral trunk examined.

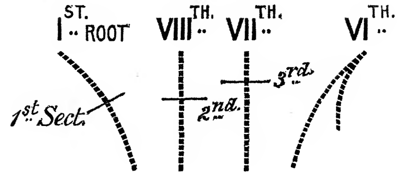
Above the elbow the posterior interosseous and the radial divisions of the musculo-spiral were easily distinguished. Five branches of the former were followed down, two branches of the latter, also a branch from the main trunk toward the external part of the triceps, and a second to the supinator longus. 1st section no effect. 2nd section appeared to reduce reply from two of the branches of the posterior interosseous division. 3rd section abolished reply from nerve toward outer part of triceps nerve to supinator longus, and from the posterior interosseous division of the nerve as a whole. Reply from radial division still obtainable though diminished. The Ist and IIIrd dorsal collateral digitals examined at this stage gave replies obviously weaker from the IIIrd than the Ist.

Experiment VI.—*Cat.* 10.7.1890.



The radial division of the musculo-spiral and the posterior interosseous gave no clear reply after the 3rd section.

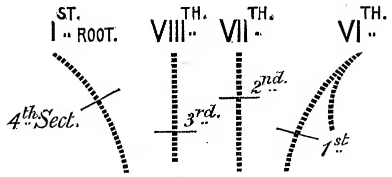
Experiment VII.—*Cat.* 12.7.1890.



Branches of the median and ulnar examined.

1st section abolished reply from none of the nerves examined. 2nd section abolished reply from the anterior interosseous (two side branches, and then the whole trunk tested), from the deep ulnar in the palm, from a branch from the ulnar trunk to the skin over the lower end of the ulna; from all the dorsal and palmar ulnar digitals, and ? from the communicating branch with the median. The replies from the median digitals were damaged toward the ulnar side—but none destroyed. The 3rd section abolished the replies from them also.

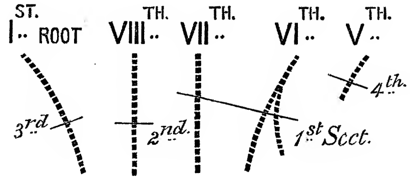
Experiment VIII.—*Cat.* 14.7.1890.



Branches of median and ulnar trunks examined.

1st section seemed to reduce the reply from the Ist palmar collateral digital (median). No other effect detected. 2nd section reduced reply from IIIrd and IVth collateral palmar digitals obviously. 3rd section abolished reply from IIIrd, and IVth, and Vth palmar collaterals, reduced it greatly from VIth, and less from VIIth. Communicating branch between ulnar and median still replies; very brisk replies from the VIIIth, IXth, and Xth palmar collaterals. A reply was obtainable from a branch of the median given off close above wrist, and passing to skin; a reply was also obtainable from muscular branches of the median near the elbow. 4th section destroyed these replies, and also reply from ulnar trunk half way up to elbow.

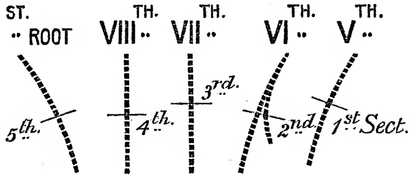
Experiment IX.—*M. rhesus.* Female. 2.9.1890.



Branches on back of hand and forearm examined.

1st section appeared to reduce, but did not abolish reply from the two most radial dorsal collaterals; it appeared to abolish reply from the musculo-cutaneous in the skin near the wrist. 2nd section abolished reply from the four most radial digital nerves, and obviously reduced it in Vth and VIth, 3rd section extinguished reply from all the ulnar digitals and from the ulnar trunk as high as 2 centims. above the wrist, where a fine twig joined it. From these upward it gave a good reply. A branch of the musculo-spiral to skin over triceps also gave a reply. These replies were not abolished by section of the Vth cervical trunk.

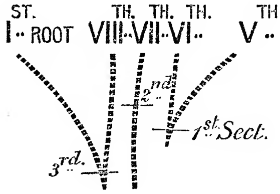
Experiment X.—*M. rhesus.* Female. 3.9.1890.



Nerves of hand and forearm, &c. Left arm.

1st section, no effect obvious on any of the digital nerves nor on branches of the musculo-cutaneous close above the wrist. 2nd section, no effect obvious on any of the digital nerves. The reply from one large branch of the musculo-cutaneous in the forearm is abolished, but not the reply from the other. 3rd section, replies from musculo-cutaneous in forearm abolished; from Ist and IInd palmar and dorsal digitales collaterales reduced. 4th section, replies from Ist, IInd, and IIIrd collateral digitals, both dorsal and plantar, abolished; from the IVth, Vth, and VIth dorsal collaterals obviously diminished; from the IVth palmar collateral obviously diminished. 5th section, replies from all the digitals abolished, also from the internal cutaneous at the elbow. But the skin over and to an inch below the inner condyle and also the skin behind the outer condyle, continued to give replies after the 5th section.

Experiment XI.—*M. rhesus.* Female. Not very young. 4.9.1890.

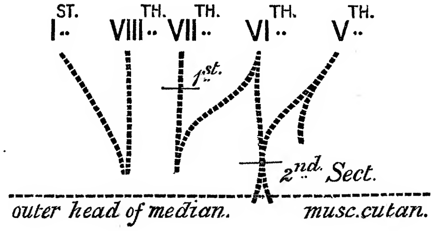


The back of the hand.

1st section reduced greatly the reply from twigs of the musculo-cutaneous along the radial edge of the forearm. Did not obviously affect any of the dorsal digital nerves. 2nd section reduced considerably the replies from the Ist and IInd dorsal collateral digitals, but did not obviously affect the rest. 3rd section abolished the replies from all the digitals, also from the ulnar, internal cutaneous, and median trunks in the axilla; also from the musculo-spiral 3 centims. above the elbow. In this experiment a striking example of local "shock" occurred; after the 2nd section no reply at all was obtainable from the Ist and IInd dorsal collaterals for 20 minutes, although later replies were easily obtained.

After the 3rd section replies were obtainable from a long region down the back of the arm to well below the elbow, and also from the front and top of the shoulder. For limits, see sketches.

Experiment XII.—*M. rhesus.* Female. 5.9.1890.



Digital nerves and others.

1st section did not obviously affect any of the digital nerves, either plantar or dorsal, at all, nor two large branches of the internal cutaneous examined half way up the upper arm. 2nd section did not obviously affect any of the digital nerves, either plantar or dorsal; the twigs of the musculo-cutaneous on the front of the forearm did not reply, but the internal cutaneous in the upper arm was not obviously affected. Two areas of greatly diminished, but not abolished, reply were found, one on the outer side of the upper arm, the second on the anterior edge of the forearm. The latter was a well-defined oval patch, rather nearer the wrist than the elbow.

The evidence regarding the root-constitution of the dorsal and collateral digital nerves of the fore foot of the Cat, given by the above experiments, is tabulated below. It differs somewhat widely from the analysis by W. KRAUSE (Rabbit) (4).

CAT. Fore foot.—Root-constitution of the collateral digital nerves.

No. of nerve-root.	Ist.	IInd.	IIIrd.	IVth.	Vth.	VIth.	VIIth.	VIIIth.	IXth.	Xth.	
VIth cervical . . .	+	+	?	..	..	..	..	..	..	..	Dorsal collat.
VIIth " . . .	+	+	+	+	+	+	+	..	..	..	
VIIIth " . . .	..	..	+	+	+	+	+	+	+	+	
Ist thoracic . . .	..	..	..	..	..	+	+	+	+	+	
VIth cervical . . .	+	..	..	..	..	..	..	..	..	..	Palmar collat.
VIIth " . . .	+	+	+	+	+	+	..	..	..	..	
VIIIth " . . .	+	+	+	+	+	+	+	+	+	+	
Ist thoracic . . .	..	..	..	..	..	+	+	+	+	+	

As the present paper deals only with the thoracic and post-thoracic spinal roots, regarding the root constitution of the collateral digital nerves of the fingers of *Macacus rhesus* it will suffice here to notice how far into those nerves the Ist thoracic root enters, as evidenced by the four experiments quoted above. With the VIIIth and Ist undivided a reflex was easily evoked from all the digitals, both dorsal and palmar, and VIIth contributes, *contra* KRAUSE, at least to Ist and IInd dorsal and palmar collaterals. There seemed to be a contribution by the Ist root as far as Vth, perhaps IVth, collateral. The IInd thoracic root, although it gives motor fibres to the muscles in the hand, does clearly from the above experiments contribute no sensory fibres to the skin of any of the fingers or to any part of the hand itself.

Experimental Series II.

From these observations on Cat and *Macacus rhesus* it appeared clear that each branch of many of the sensory nerve-trunks in the limb consists of fibres which enter the cord by two or three distinct posterior roots, and that, therefore, just as there is a great interlapping of the limb territories of adjacent spinal nerve-roots judged by their distribution to the skeletal muscles, so also a great interlapping is evidenced in the distribution of the afferent fibres from the skin. It was also clear that as in the afferent roots of the Frog, so also in Cat and Monkey, some amount of individual variation is frequent. Points of interest especially requiring confirmation as unexpected and not in harmony with the observations on the Frog, or with the scheme of distribution of efferent fibres of the plexus, were the following. Among the conclusions arrived at from the experiments on the Frog is this: the cutaneous field for each posterior root meets the middle line of the body both ventrally and dorsally. In the Cat and Monkey after the above analysis of the constitution of the peripheral branches of the plexus it was clear the skin field of post-thoracic root VI could not possibly attain the dorsal or the ventral lines, it seemed roughly speaking to be distributed entirely to the apex of the limb—again, in the scheme of distribution to the musculature of the limb, the most segmentally posterior of the rays composing the limb penetrates to the very apex of the limb, both in the arm and leg. To judge from the above experiments this does not appear true for the segmental constitution of the *skin* of the limb. The posterior root of the VIIIth nerve does not appear to penetrate so far into the limb as does that of the VIth. That is to say, the limb being considered as a fin-like appendage, the musculature has a posterior border which is straight and abrupt, and formed out of one ray, the overlying skin has a posterior border which is slanting and gradual and composed of more than one ray. Again as regards the musculature it was often the case (in the post-fixed type of plexus) that root IX contributed well to the innervation of the limb. This root does not (according to the above experiments) contribute to the skin of the limb proper; therefore the skin to which it supplies afferent fibres and the muscle to which it supplies motor fibres are separated by nearly the whole length of the limb, breaking the rule set down by VAN DER KOLK,* PEYER (2), KRAUSE (4), and others. In order to obtain a clearer answer on these points I attempted a direct delimitation of the spinal sensory root-fields in the Mammal, in the same way as in the already cited experiments on delimitation of the root-fields in the Frog. An essential feature in these experiments consisted in severance of a sufficient number of nerve-roots immediately above and below the root examined to make a field of anæsthesia, on which as on a blank surface the territory of the æsthesia subserved by the isolated root could be mapped. The preparatory procedure of experiment was the same as for the observations on the root-composition of the various peripheral nerves, but of course no exposure of peripheral nerves was employed or necessary, mechanical excitation of the skin being substituted for mechanical and electrical excitation of the nerve trunks. The same recording method was employed in the Frog's experiments; that is, each point of the previously shaved skin that gave a reply was marked (with ink) at the time, and no other points were ever marked. After the whole area had been once explored in this way, a process which might occupy two or three hours, the extreme limit of the area was indicated by a white line carried on from reply spot to reply spot. After an interval of perhaps an hour this boundary-line was then very carefully and minutely explored at about 5-minute intervals, and the first white line was thus corrected as regards its detailed contour. After a few experiments on certain roots, especially root VI, it became evident that in this way a fairly constant figure was arrived at for the same root, subject to comparatively minor variations; it also became evident that the root distribution was such that in order to isolate one root-territory, in some cases so many as seven consecutive posterior roots above or below had to be severed. Some time and labour was wasted by my not recognizing this fact early enough, and its explanation will be dealt with after relating the experiments in which it occurred.

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* FRORIEP'S 'Notizen.' 3rd series. 1847.

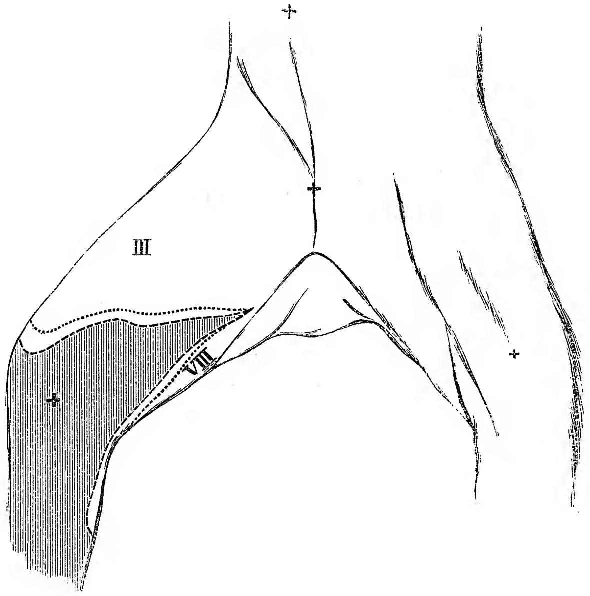
Regarding the form of stimulus used, the skin was pinched with a fine pointed pair of dissecting forceps, and sometimes a mere touch sufficed to elicit a reflex; at other times, especially near the edge of the root territory, a hard pinch had to be employed. At first I attempted to keep a record of the areas obtained by transferring them to "proportional paper" as in mapping from the microscope by means of the movable stage and squared eye-piece: difference of size and proportion, between individual and individual frustrated this attempt, the maps becoming too confusing from necessary absence of perspective and inability to follow accurately the two superficial dimensions of a very irregular solid figure. I then proposed to content myself with accurate measurements from comparatively fixed points and written description, illustrated with pencil sketches; the difficulty of obtaining accuracy with the latter, induced me to record with photography at the latter part of each experiment or immediately after it. As it was found that for photography in winter in London the ink marks often did not show up sufficiently on the pigmented skin, in the later experiments the boundary of the territories was usually indicated by a double line of white and black, the white border turned toward the side which yielded reflexes, the black toward that which did not yield reflexes. Finally plaster casts of *Macacus rhesus* were made under my own direction by Messrs. BRUCCIANI, and the position of the chief bony points accurately transferred from the individual whence the casts had been taken to the casts. Then the territory of the nerve-root desired to be transferred to the plaster model was delimited on an individual of approximately the same size as the cast, and in that way the model was gradually covered with the pattern of the various root territories. It was only when that had been done that certain important points in the scheme of their arrangement became salient. Several reasons led me beyond the limits of the lower limb in this part of the research.

In the series of experiments in which analysis of peripheral nerves into their root-composition was attempted by electrical excitation of the nerve and successive sections of the contributing roots, it was usually found that when one of the roots that contributed largely to, for instance, a small digital collateral nerve, had been severed, a very weak reply or no reply could be evoked from the proximal end of the digital nerve for a few minutes immediately subsequent to the section of the root; but if tested about twenty minutes later it gave a better reply, or even a smart reply, when previously there had been none. At first I imagined this the result of some adventitious error in the excitation. Later, one recognized the phenomenon as in some degree or other of constant occurrence. The same phenomenon has recurred in the last quoted series of experiments in which instead of analysis of nerve-twigs under electrical excitation, analysis of root-fields under mechanical excitation, has been the method. If the isolated *field of response* was delimited very soon after the posterior roots immediately above and below that distributed to the root-field under examination had been severed, a field was obtained of the approximate shape of the true root-field but smaller than it, and curtailed especially in certain directions. When examined later, the field of response, determined by exactly the same method as before, was found to have extended. The following instances exemplify this phenomenon.

Experiment.—*M. rhesus.* 20.10.1890.

The Vth, VIth, VIIth, IXth, and Xth roots (posterior) of the post-thoracic region severed on the right side, at 10.50. At 11 o'clock the delimitation of the areas carried out first. At 9.30 P.M. the delimitation of the areas carried out finally. The lower limit of the VIIIth root field has travelled downward 3·5 centims., that of the IVth about 1·4 centims. at greatest. The upper limit of the VIth and VIIIth root fields combined had advanced about ·8 centim. toward the perineum at greatest.

Fig. 3.

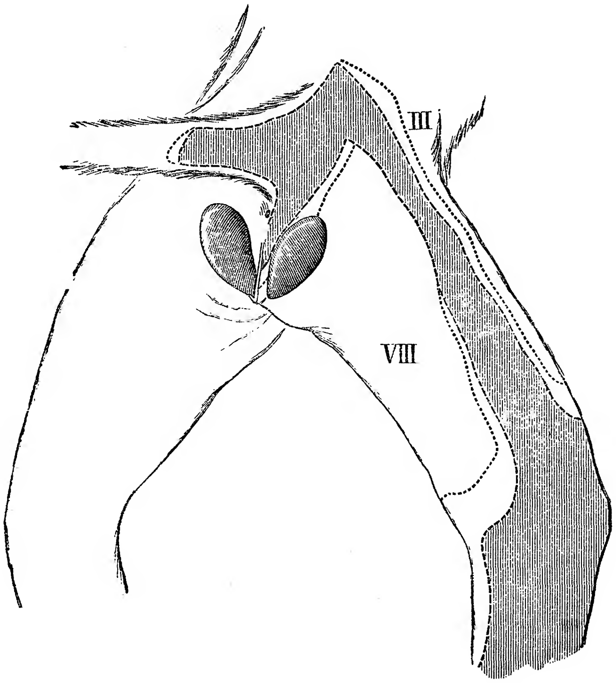


Experiment.—*M. rhesus.* 4.5.1891.

The posterior roots of the IVth, Vth, VIth, VIIth, IXth, and Xth post-thoracic spinal nerves of the right side severed in the spinal canal at 9.10 A.M. At 9.20 the delimitation of the field of the VIIIth post-thoracic root was carried on. The result was that the lower margin was placed distinctly above the flexure of the knee. (See figs. 3, 4, sketches made at the time.) At 4 o'clock the field of the VIIIth root was delimited again, and without hesitation the lower margin of the area was placed distinctly in the flexure of the knee and in part for a certain distance below it. (Figs. 3 and 4, the same sketch as before.) The upper margin had also extended, but not so far, in the direction of the perineum and along the labium of the vulva. It was especially noticeable that there had been no obvious extension along the border turned toward the field of the IIIrd lumbar. That is to say, the advance had been confined to the anterior and posterior borders of the root field and had occurred but little at the dorsal and ventral borders. (See Conclusions, *infra*, p. 742.)

The second of the two experiments quoted was performed to determine the nature of the "extension of the field" in regard to the two borders, and the rate of extension at different periods; regarding the latter point it was found that the rate of "extension" was greatest in the first half-hour, and that in the third hour and afterwards there was little if any further progress of the field. I have been used to call the initial lowering of response, the "local spinal depression," and the subsequent increase of response and the accompanying increase of the area of reply, the "local spinal exaltation," and the "extension of the field." During the period of "local spinal depression" the responses besides being enfeebled are often of curiously long latency. The period of "local spinal depression" has often seemed to me to be shortened in duration by repetition of excitations, even when these are at first inefficient to evoke obvious responses.* The whole phenomenon appears quite comparable to the transient depression and subsequent exaltation of the "knee jerk" produced in, for instance, the Cat by section of the spinal cord above the lumbar region. And the briskness of the "jerk" may in like manner be increased by section in the spinal canal of the spinal roots, either sensory or motor, adjacent to that one most intimately concerned with the jerk, and especially of the

Fig. 4.



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* An example of the physiological process called by Exner "Bahnung," Pflüger's 'Archiv f. d. ges. Physiol.,' vol. 28, p. 487.

muscular nerves to the antagonists of the "jerk" muscles. In the field of a root immediately above severed roots, or immediately below severed roots, a marginal area of unmistakably exalted reflex reply is sometimes found. This is due, I imagine, to the "local spinal exaltation" and is an evidence of the local character of the exaltation. It may be essentially the same phenomenon as the hyperæsthetic zone bordering a paralyzed area (FODÉRA, 1823*) after lesions of the spinal cord itself. The "local spinal exaltation" is of great assistance to the above method of delimiting the cutaneous spinal root fields; the whole field of the root isolated by sections of adjacent roots is more or less affected by the exaltation. In one of the experiments in which one half the rootlets of the posterior division of the VIth lumbar spinal root were cut through after previous section of the adjacent roots, it seemed clear that in the plantar region the reflex response was *increased further* after the section of half the rootlets of the spinal root. As to the length of time which the phenomenon lasts I can say little, but the exaltation of the knee jerk after section of adjacent roots I have seen persist for more than three months. Of course it must be remembered that in that case the loss of the tone of the muscles antagonistic to those on which the jerk depends may play a main part in the production of the exaggeration of the jerk. The influence of a sensory root on the activity of the motor, or of blocking one motor root on the activity of another, is too far from the present experiments to be entered upon here, but I have attempted to see whether the "local spinal depression" could be demonstrated to affect the reaction of the anterior root to cortical excitation, and I have not been able to show that it does. Two experiments were made with a similar result, which evidenced rather local exaltation than depression.

Experiment.—*M. rhesus*. Female. 11.2.1891. A.C.E. mixture. Cord exposed in the canal.

11.25 A.M. Excitation of central end of each of three filaments (about 4 centims. long) of the posterior root of the Vth post-thoracic nerve elicited reflex movements (secondary coil at 39 centims. from primary: EWALD's inductorium with 1 Daniell), slight eversion of foot, followed by slight adduction and flexion of hallux, rarely followed by abduction and slight extension of hallux. Each of the filaments when strength of excitation is increased gives flexion at hip (*i.e.*, drawing up of knee), no extension of knee, but some extension at ankle, and in digits and hallux. The most marked feature of the reflex with all the strengths (from 39 centims. to 25 centims.) was the action of the peronei.

11.50. Left "motor" cortex exposed. Excitation at the top of the central sulcus gave movements of the hallux, and, with stronger excitation, of the foot. The movements of the hallux sometimes extension, sometimes flexion.

12.20. The posterior roots of the VIth, VIIth, VIIIth, and IXth post-thoracic nerves of the right side have silk thread carefully slipped under each. (Vth root already cut.)

12.28. The central ends of the three filaments excited each as before; each gives similar reflex reply, and the replies are not distinguishable from those obtained before.

12.42. Cortex excited. Flexion of hallux obtained with minimal current (secondary coil at 17 centims.).

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* MAGENDIE's 'Journal de Physiologie,' vol. 3, p. 191.

12.46. Cortex excited once at same spot. Same movements obtained with secondary at 17 centims. Coil at 18 not effective.

12.48. The posterior roots of the VIth, VIIth, VIIIth, and IXth post-thoracic nerves all rapidly cut through with scissors (in about 40 seconds).

12.54. Cortex excited at same spot as before (coil at 17 centims. from primary) gives as brisk movement of hallux (flexion).

12.59. Cortex for hallux and fingers responds to excitation at 19 centims.

1.4. Cortex for hallux responds at 19 centims. Reply is brisker than before.

1.10. Cortex for hallux responds at 21 centims.; at 20 hallux and fingers both respond well.

On February 23 a similar experiment was made, with the same result.

In describing the experiments the use of a few special terms is unavoidable:—

The *mid-dorsal line of the body* to denote the middle line of the dorsal surface of the animal, the surface consisting of right and left halves, which meet at the mid-dorsum.

The *mid-ventral line of the body* to denote in a similar sense the middle line of the ventral surface of the animal.

The *mid-lateral line of the body* to denote a line of surface equidistant from the mid-dorsal and mid-ventral lines of the body.

The mid-dorsal and the *mid-ventral lines of the limb* are lines on the limb surface, along which the skin fields of the sensory roots behave as if at the mid-dorsal and mid-ventral lines of the body. See Plate 52.

The *dorsal border* of the skin field of a root is that border which follows the mid-dorsal line; the *ventral border* that border which follows the mid-ventral line.

The *anterior border* of the skin field is that border of the field which runs between the most anterior (headward) point of the dorsal border and the most anterior point of the ventral border. The *posterior border* of the skin field runs between the most posterior point of the dorsal border and the most posterior point of the ventral border.

(For *anterior* and *posterior overlapping* and *dorsal* and *ventral crossed overlapping*, see p. 652 *supra*, and Plate 52.)

The experiments are arranged in an order that traces the distribution of the posterior roots in series from before backwards on the long axis of the body.

Ist Thoracic.

Experiment.—*Macacus rhesus*. Female. 22.6.1891.

At 11.10, the posterior divisions of the Vth, VIth, VIIth, VIIIth cervical and IInd, IIIrd, and IVth thoracic nerves of the right side divided in the spinal canal. At 4.30, the isolated region of reply (*i.e.*, of *Ist thoracic*) delimited finally.

"The isolated field of response is bounded by a line that is traceable from the ulnar side of the proximal phalanx of the middle digit, backward and upward over the knuckle of that digit to the back of the lower end of the radius over the tendon of the extensor carpi radialis brevior; thence the line advances toward and reaches the radial edge of the forearm at junction of middle and lowest thirds; then it slopes toward the ulna, and, in the highest third, runs straight up, so as to lie midway between the external condyle and the skin-fold over the biceps insertion. At the level of the head of the radius, the line turns abruptly backward passing about ·5 centim. above the outer condyle round to just above

(3 millims.) the olecranon. Winding round the olecranon at a point 1 centim. above the internal condyle, it then turns sharply upward, ascending on the axillary aspect of the arm about 1 centim., or less, behind the biceps (on the triceps side) to a level with the deltoid insertion; at that place it recurves upon the biceps, and, winding round that muscle, slants down first on the inner face, and then on the front of the belly of the muscle, so as to pass into the hollow to the ulnar side of the supinator mass at the flexure of the elbow. It then tends at first a little in the direction of the ulnar edge, and soon runs down the middle of the flexor aspect of the forearm to enter the palm, crossing the wrist in the groove between the thenar and pisiform eminences. It finally reaches the flexor aspect of the proximal phalanx of the middle finger a little toward its ulnar side, and then attains the point it started from."

Measured:—

Suprasternal notch to infrasternal	9	centims.
" " mammilla	4·5	"
" " umbilicus.	18·5	"
" " pubic crest	26	"
Acromion to tip of 3rd digit	31·5	"

Twelve ribs each side. No extra mammillæ.

Ist Thoracic.

Experiment.—*Macacus sinicus.* Male, young. 25.5.1891.

Measures:—

From suprasternal to infrasternal notch	6	centims.
" " " crest of pubes	22	"
" head of humerus to tip of 3rd digit	26·5	"
" nipple to infrasternal notch	4	"

At 10.30, the posterior divisions of the VIth, VIIth, VIIIth cervical and the IInd, IIIrd, IVth, and Vth thoracic spinal nerves of the right side divided in the spinal canal. At 2.10, delimitation of field of response completed.

"The line then turns back over the olecranon, and outwards to the point of the outer condyle, and across in front of the brachial fold to outer edge of biceps just above its insertion; it then bends sharply and runs down toward the hand, sloping outwards so as to cross the outer surface of the radius a little below the middle of that bone. It crosses the wrist about midway between the radial and ulnar styloid processes and bisects the back of the hand. It then curves outward to reach the base of the little finger. It enters the palm over the web between 5th and 4th digits, and runs upward curving outward so as to include the inner third of the thenar eminence. At the front of the wrist it lies a little to the radial side of the middle. It keeps somewhat to the radial side of the middle line of the forearm to the skin over the outer side of the insertion of the biceps tendon."

In this experiment, the field of the Ist thoracic was not distinguished from the field of the Vth cervical, but the separation is easy in the light of subsequent experiments, as the two fields are only apposed over a little space.

Twelve ribs each side.

IInd Thoracic.

Experiment.—*M. rhesus.* 5.8.1891. Plate 42, fig. 1.

Measurements as on p. 699.

At 12.30 the Vth, VIth, VIIth, VIIIth cervical, the Ist, IIIrd, IVth, Vth, VIth thoracic roots of the right side divided.

At 8.10 the final delimitation of the skin field of the IInd thoracic root.

"The isolated field of reply is not perfectly isolated, it joins, by a band of low irritability, the upper field of reply" (IVth cervical). "The extent of this imperfect fusion of the two fields measures about 2·5 centims. The posterior edge of the isolated field must be the edge that is nearest the spine at the junction with the lower edge of the upper field of reply, and that junction is over the triangular subcutaneous piece at the root of the spine of the scapula. From that place the edge descends first, and then runs outward over the infraspinous fossa at 1 centim. above the inferior angle of the scapula, and then along the posterior fold of the axilla to the upper arm, reaching the actual crest of the ridge of it at the angle of junction of the arm and trunk (at the shoulder). It then tends down the thoracic wall a little way forming a shallow, broad tongue, and runs down the arm again, crossing to the biceps side of the axillary groove of the upper arm, and nearly coming in contact with the upper field on the upper part of the belly of the biceps." "Close below the lowest point to which the field attained on the arm was a little oval area about 2·5 centims. long, which gave replies, and yet could not be clearly shown to actually be continuous with the main area. This islet was the lowest point to which the field attained on the limb."

Normal number of ribs (twelve) each side, verified by *post-mortem* examination.

IInd Thoracic.

Experiment.—*M. rhesus.* Female; strong. 18.6.1891.

Dimensions as on p. 699.

At 11.30 A.M. the IIIrd, IVth, VIth, VIIth, VIIIth cervical, and Ist, IIIrd, IVth, and Vth thoracic roots of the right side severed.

At 6.10 the lower of the isolated fields of reflex reply finally delimited (*i.e.*, the field of the IInd thoracic root).

"The boundary of the lower of the isolated fields of reply extends from a point one-third down the forearm at the junction of the ulnar and flexor aspects, thence upwards, sloping across the subcutaneous surface of the root of the olecranon, and up the space between the olecranon and the inner condyle. Thence it passes up the upper arm along the middle of its posterior aspect on the subcutaneous surface of the triceps just behind the biceps and just behind the deltoid muscle, to meet the spine of the scapula at its junction with the root of the acromion; and then returns, and soon recurves upward again, and retires again. It thus leaves a Y-shaped piece with a double tongue, each tongue about 2 centims. wide, the upper passing across the axillary border of the scapula, to as far as the scapular spine, the lower not quite reaching that retiring scapular edge, but getting to within less than a centimetre of it. The lower tongue runs, in fact, down the fold of muscle covering the scapular edge, and turns up upon it again, so that it follows the posterior fold of the axillary space for a certain extent, and comes down the upper arm in the groove, or a little behind the groove between the triceps and biceps muscles. It so comes to lie in front of, *i.e.*, on the flexor face of, the muscular origins from the inner condyle, and then reaches the point it was traced from about one-third down the forearm."

The normal number of ribs present. Two pairs of nipples.

IInd Thoracic.

Experiment.—*M. rhesus.* Female; strong. 10.6.1891.

Dimensions:—

Suprasternal notch to pubic crest . . .	30	centims.
,, ,, infrasternal notch .	10	,,
,, ,, nipple	4·5	,,
Acromion to tip of 3rd digit	28	,,

At 9.10 the IIIrd, IVth, Vth, VIIth, and VIIIth, and the first two thoracic roots of the right side severed.

At 5.30 the anterior border of the field of the IIIrd thoracic finally ascertained.

"The upper edge of the lower field of reply runs from the ventral cross-lap 2 centims. above the intermammillary line, horizontally outward over the nipple to the pectoral fold 2 centims. from the arm; along that fold it descends upon the biceps, then on to the coraco-brachialis, to slope out to the triceps about 2 centims. above the flexure of the elbow; it descends to the top of the elbow in a straight line, and passes up again, at first between the outer and middle portions of the triceps, to strike the outer edge of the scapula half way up it. It passes over the junction of the base of the spine of the scapula with the triangular space at the root of the spinous process, and then slopes down and inward. It leaves the vertical edge of the scapula at the above-mentioned triangular space, and meets the mid-dorsal line about on a level with the mammilla, or somewhat lower than that."

Twelve ribs existent each side.

IIIrd Thoracic.

Experiment.—*M. sinicus.* Young male. 28.5.1891.

Measured:—

Acromion to tip of 3rd digit .	29 centims.
Sternum	8·8 ,,

At 8.50 the VIIIth cervical, the Ist, IInd, IVth, Vth, VIth, and VIIth thoracic roots (posterior roots) of the right side severed.

At 5.10 the final delimitation of the field of reply due to the IIIrd thoracic root.

"The lower edge of the almost isolated field of response can be traced from a ventral crossed overlap on the sternum about 5 centims. below the clavicle, and from that point slants outward and upward to cross the nipple line about 0·4 centim. below the nipple. It then runs, if the arm be extended at right angles to the trunk, in a slightly ascending direction as far as the mid-axillary line. It then slightly descends so that its lowest point is where it sweeps round the posterior axillary fold. After that it runs horizontally across the inferior angle of the scapula (arm horizontally extended to a point about 2 centims. from the mid-dorsal line). Thence it abruptly turns upward to reach the lower border of the scapular spine at the medial edge of the scapula. It runs along the lower border of the spine of the scapula outward, descending slightly below it at its outer end. It reaches a point half way between the tip of the acromion process above, and the lower border of the triceps at the junction of the arm and shoulder. At that point it meets another line limiting the upper field of reflex response. Parallel with this line it descends the back of the upper arm to within 2 centims. of the olecranon; at that distance from the elbow it curves inward and then returns up the arm along the inner edge of the triceps mass. It passes upward and inward across the thoracic wall of the axilla. Finally, on the border of the pectoral fold it meets again the lower limit of the upper field of response, and is not further isolated from it."

IIIrd Thoracic.

Experiment.—*M. sinicus.* Female, young. 26.8.1891. Plate 42, fig. 2.

Measurements:—

Length of arm from acromion to tip of 3rd digit	23 centims.	
From suprasternal notch to pubic crest	21·5 ,,	
,, ,, umbilicus	14 ,,	
,, ,, mammilla	4 ,,	(obliquely)
,, ,, infrasternal notch	7·4 ,,	

At 8.50 A.M. the IVth, Vth, VIth, VIIth, VIIIth cervical, the Ist, IInd, IVth, Vth, and VIth thoracic roots of the right side divided.

At 5.30 the cutaneous field of the IIIrd thoracic delimited finally.

"The upper edge of the isolated field of reply extends from the mid-ventral line 1·5 centim. below the lowest edge of the upper field of reply" (IIIrd cervical) "that is 2 centims. above the nipple horizontally outward for 2·5 centims. till it meets the anterior axillary fold. It then runs parallel to that fold, but on the anterior surface of the pectoral eminence about 0·3 centim. above that fold. It then turns down the biceps (inner edge), probably on the coraco-brachialis to the bicipital space (inner edge) nearly as low as a line joining the condyles of the humerus. It retires 0·5 centim. and then winds round the inside of the arm about 1 centim. above the inner condyle, reaching the posterior surface of the arm 1 centim. above the olecranon (arm extended). The line then abruptly ascends the arm on the triceps fold rather nearer the lower than the upper border of the arm (arm horizontal). It enters the infraspinous fossa about half way up the axillary border of the scapula, and reaches the posterior edge of the scapula just below the triangular subcutaneous piece at the base of the spine of the scapula. It then turns at an acute angle outward, and crosses the infraspinous fossa to the outer border, which it reaches close above the inferior angle of the scapula; it ascends again a little distance, winding round the scapular fold and crossing the thoracic wall of the axilla above the level of the nipple, but always slightly descending; it then winds round the thorax, sloping slightly downward and passing about 0·2 centim. below the nipple to reach the mid-ventral line."

IIIrd Thoracic.

Experiment.—*Macacus rhesus.* Female. 6.4.1891.

Dimensions:—

Head to 3rd digit, point of .	11 centims.
Nipple to sternal notch . .	4 „
Ankle to knee	13 „
POUPART'S ligament to knee	11·5 „

At 10.30 the roots of the IVth, Vth, VIIth, and VIIIth thoracic nerves of the right side divided in the spinal canal.

At 3.20 the lower border of the field of the IIIrd thoracic root determined.

"The lower edge of the upper field of reply starts from the mid-dorsum somewhat above half way up the scapula; it slopes slightly downward as it passes outward, and, crossing over the infraspinous fossa of the scapula, turns the axillary border over close under the posterior angle of the axillary space, crosses the thoracic wall of the space and meets the pectoral fold a little above the level of the nipple. The line then runs horizontally above the nipple, passing just above it, to the ventral crosslap on the sternum."

IVth Thoracic.

Experiment.—*M. rhesus.* Female, strong. 22.10.1891. Plate 43, figs. 3 and 5.

Dimensions:—

From suprasternal notch to infrasternal . . .	9 centims.
From infrasternal notch to pubic crest. . . .	18·5 „

The IVth, Vth, VIth, VIIth, VIIIth cervical, and the Ist, IInd, IIIrd, Vth, and VIth thoracic roots of the right side severed at 11.15. At 7.30 the field of the isolated IVth thoracic finally delimited.

"The upper edge of the isolated field of reply passes almost horizontally from the mid-dorsal line to the border of the scapula at the lowest point of the triangular surface at the root of the spine of the scapula. It slopes a little downwards in crossing the scapula, and runs down the back of the arm as far as one-third the way to the olecranon. It there returns and enters the axilla, penetrating to the apex of the axillary space. It winds over the edge of the pectoral fold so as to reach its anterior aspect halfway between the origin and insertion of the thoracic part of the pectoralis major. From that place it slopes downward and meets the mid-ventral line on the sternum at the lower edge of the 2nd costal cartilage. It there lies nearer to the lower edge of the upper field of reply (IIIrd cervical root) than to the mammilla.

"The lower edge of the isolated field of reply passes from the mid-dorsal line, about 3 centims. below the point of commencement of the upper edge from that line. It slopes more steeply downward than does the upper edge, and therefore does not run parallel with it. It passes outward close below the inferior angle of the scapula. From that point, sloping less than it has done, it runs fairly directly toward the mid-axillary line. In that line it passes just below the lower border of the 5th rib. It then ascends somewhat, and runs more horizontally to meet the mid-ventral line on the sternum at the upper border of the sternal end of the 5th costal cartilage. Its distance from the nipple in the vertical of the nipple is 1·5 centim. (below it).

"The nipple is situate, when measured on the cage of the thorax (by transfixion), midway between the apices of the 2nd and 3rd ribs. After the above field has been delimited it is seen that the nipple lies in it about midway between the anterior and posterior edges of the field.

"The field reaches its greatest vertical depth about 2 centims. in front of the inferior angle of the scapula, where, when the tongue-shaped extension down the arm is included, it has a breadth of 7 centims. The field is shortest at the mid-dorsal line, where it measures 2·5 centims. It is next narrowest at the mid-ventral line, where it measures 3 centims."

IVth Thoracic.

Experiment.—*M. rhesus.* Female. 2.6.1891.

Dimensions when the arm is extended at right angles to the trunk :—

Suprasternal notch to crest of pubes .	23	centims.
Acromion to top of 3rd digit	26·5	„
Infrasternal notch to suprasternal . .	7·1	„
„ „ mammilla . . .	4·5	„
Suprasternal notch to mammilla . . .	3·5	„

At 9.5 the IVth, Vth, VIth, VIIIth cervical, and the Ist, IInd, and IIIrd thoracic roots of the right side severed. At 4.10 the upper edge of the cutaneous field of the IVth thoracic fully ascertained.

"The upper edge of the lower field of reflex reply extends from the ventral crosslap on the sternum outwards, passing 1·5 centim. above the nipple, and reaching a point 3 centims. from the mid-ventral line, from which point it slopes upward and outward to cross the wall of the thorax in the axilla. It winds round the pectoral fold about midway up it, and passes on to turn downward inside the fold over the latissimus dorsi, and then bends backward on the inner head of the triceps about one-third the way down the upper arm. When it has attained the middle line of the posterior aspect of the upper arm, a little below the junction of the middle and upper thirds of the arm, it turns abruptly upward, and keeping to the crest of the triceps prominence it strikes the outer edge of the scapula rather more than a quarter up it. It passes across the scapula to the lowest point of the triangular space at the root of the scapular spine, and then it slopes downward to attain the mid-dorsal line at a level lower by 1 centim. to 2 centims. than the level at which it commenced when traced from the mid-ventral line; a level below the inferior angle of the scapula when the arm is extended horizontally."

Number of ribs verified as normal at autopsy.

IVth Thoracic.

Experiment.—*M. rhesus.* Female; young. 17.12.1890.

Measured:—

Umbilicus to pubes	8·5 centims.
Nipple to pubes	21·5 ,,

At 11.30 the Vth, VIth, VIIIth, and IXth thoracic roots of the right side severed. Final delimitation of the border of the IVth thoracic at 5.20.

"The posterior (lower) edge of the upper field of reply extends from a point on the mid-dorsal line 12 centims. above the level of the anterior superior spine, and from that point passes almost horizontally outwards just below the inferior angle of the scapula (in the raised position of the arm) and slopes slightly downward over the lateral aspect of the chest, running 2 centims. under the nipple and reaching the mid-ventral line on the sternum, perhaps somewhat less than 2 centims. below the inter-mammillary line."

Ribs twelve in number in this individual.

Vth Thoracic.

Experiment.—*M. rhesus.* Female. 7.6.1891.

Measurements when arm is at right angles to trunk:—

Tip of middle digit to acromion	27 centims.
Suprasternal notch to infrasternal	7 ,,
,, ,, umbilicus	16 ,,
,, ,, crest of pubes	24 ,,
,, ,, mammilla	4 ,,

At 10.45 the IVth, Vth, VIth, and VIIth cervical, and the highest four thoracic nerve-roots, severed on the right side. The anterior border of the cutaneous field of the Vth thoracic, estimated finally at 7.15.

"The upper border of the lower field of reply runs from the ventral crossed overlap ·5 centim. above the nipple, horizontally outward to the anterior pectoral fold, then turns up that fold for about 1 centim. and down again to cross the thoracic wall of the axillary space about on a level with its point of origin. It then reaches the latissimus dorsi fold and runs round it in the angle of junction of the arm with the posterior axillary fold, and gets upon the scapula by crossing the axillary border of it at junction of the middle with the lowest third. The line strikes the spinal ridge of the scapula about ·5 centim. below the base of the spinous process. From that point it slopes downward to reach the mid-dorsal line 3 centims. lower, *i.e.*, about 1·8 centim. lower than the junction with the ventral crossed overlap."

Found, *post-mortem*, to have twelve ribs on each side.

Vth Thoracic.

Experiment.—*M. rhesus.* Female. 22.6.1891.

Measurements, with the arm horizontally extended:—

Suprasternal notch to infrasternal	9·5 centims.
,, ,, mammilla	4·5 ,,
,, ,, umbilicus	18·5 ,,
,, ,, pubic crest	25·5 ,,
Acromion to tip of middle digit	31·5 ,,

At 10 A.M. the lowest four cervical, and the IInd, IIIrd, and IVth thoracic roots severed on the right side.

At 4 A.M. the anterior border of the skin field of the Vth thoracic root finally delimited.

"The anterior border runs from the ventral crossed overlap, 3 centims. below the suprasternal notch, outward 1 centim. above the nipple, thence to the edge of the pectoral fold, and up that fold to pass on to the arm and follow the apex of the deltoid triangle round to the back, but about ·75 centim. below, *i.e.*, distal to the triangle, so as to extend very nearly half-way down between the acromion and the flexure of the elbow; thence the border turns upward following the deltoid, and then across the scapula, gradually approaching the ridge of spinous process, and over the triangular subcutaneous space at the root of that process, leaving the scapula on a level with the base of the spinous process, to descend slightly from that in a straight line to the mid-dorsal line."

VIth Thoracic.

Experiment.—*M. sinicus.* Male; young. 25.5.1891.

Measurements with arm extended horizontally:—

From suprasternal notch to crest of pubes	22	centims.
,, ,, ,, infrasternal notch	6·5	,,
,, acromion to tip of 3rd digit	26·5	,,
,, nipple to infrasternal notch	3·25	,,

At 2 P.M. the VIth, VIIth, and VIIIth cervical roots, and the IInd, IIIrd, IVth, and Vth thoracic roots severed on the right side. The anterior border of the cutaneous field of the VIth thoracic, finally examined at 8 P.M.

"The anterior edge of the lower field of reply runs from 1·5 centims. above the infrasternal notch, from a good 1 centim. crossed overlap, outwards and upwards to a little less than 1 centim. below the nipple in the nipple line; the edge then passes almost horizontally to 2 centims. behind the mid-axillary line, where it rises somewhat, and then sinks posteriorly, sloping backward to meet the mid-dorsal line just about the level at which it strikes the mid-ventral line in front."

At the autopsy twelve pairs of ribs were found.

VIth Thoracic.

Experiment.—*M. rhesus.* Female. 6.4.1890.

Measurements:—

Heel to tip of 3rd digit	11	centims.
Nipple to sternal notch	4	,,
Ankle to knee	13	,,
POUPART'S ligament to knee . . .	11·5	,,

The roots of the IVth, Vth, VIIth, and VIIIth thoracic nerves of the right side divided in the spinal canal at 10.35.

At 3.50 the field of the VIth thoracic root delimited.

"The lower edge of the isolated field of reply runs from the mid-dorsal line about 1·5 centims. above the inferior angle of the scapula outwards, and downwards out of the lower part of the infraspinous fossa to the side of the chest. It lies in the nipple line below the level of the infrasternal notch, and about 5 centims. below the nipple. It reaches the ventral crossed overlap 8·5 centims. above the umbilicus, which is rather further above the umbilicus than the umbilicus is above the pubic crest, and much nearer the level of the nipple than of the umbilicus."

"The upper limit of the isolated field of reply extends from the mid-dorsal line a a point about

2·5 centims. above the point whence the lower limit starts. With very little curving it turns outward and slopes over the scapula across the thoracic wall of the axilla, to bend round the edge of the pectoral fold about 2 centims. below the level of the nipple, and cross at about that distance below the nipple to reach the ventral crossed overlap of the sternum at the base of the xiphoid process."

VIth Thoracic.

Experiment.—*M. rhesus.* Female; strong. 18.6.1891.

Measurements when the arm is extended horizontally:—

From suprasternal notch to infrasternal	8·5 centims.
,, acromion to top of middle digit	30·5 ,,
,, suprasternal notch to pubic crest	31·5 ,,
,, ,, ,, nipple	4 ,,

The following roots were severed at 11.30 A.M.:—The IIIrd, IVth, VIth, VIIth, and VIIIth cervical, the Ist thoracic, the IIIrd, IVth, and Vth thoracic on the right side.

Final delimitation of the anterior border of the skin field of the VIth thoracic at 8.30.

"From the ventral crossed overlap about ·5 centim. below the large uppermost thoracic nipple, about horizontally outward to the mid-point of the axilla; thence it ascends somewhat, and descends, passing backwards close below the inferior angle of the scapula, and thence horizontally inwards to the mid-dorsal line."

Post-mortem examination proved the ribs to be twelve in number. Two pairs of nipples, of which the upper corresponds with the pair usually present.

VIIth Thoracic.

Experiment.—*M. rhesus.* Female; young. 5.8.1891.

Measures:—

From suprasternal notch to crest of pubis . . . . 28 centims.

At 12.40 the following roots severed on the right side:—The Vth, VIth, VIIth, and VIIIth cervical; the Ist, IIIrd, IVth, Vth, and VIth thoracic. Final delimitation of the anterior border of the skin field of the VIIth thoracic was made at 9.30. The upper edge of the lower field of æsthesia passes from a point in the mid-sternal line on a level just below midway between the nipple and the infrasternal notch, and passing round 2·5 centims. below the nipple reaches the mid-dorsal line over the 4th dorsal vertebra.

Post-mortem examination found twelve ribs each side.

VIIth Thoracic.

Experiment.—*M. rhesus.* Female; young. 17.12.1890. Plate 43, fig. 4.

Measured:—

Umbilicus to pubes	8·5 centims..
Nipple to pubes	21·5 ,,

At 11.30 the Vth, VIth, VIIIth, and IXth thoracic roots of the right side severed.

Final delimitation of the border of the VIIth thoracic at 6.30.

"The anterior edge of the isolated field of reply passes from a point in the mid-sternal line about 6 centims. below the nipple, outwards, and somewhat rapidly upwards, to cross the nipple line 3·5 centims. below the nipple, and after extending horizontally, again sweep upward so as to reach a level about 2 centims. below the nipple level, and thence run almost horizontally inwards to the mid-dorsal line, which it attains at a point about 2·8 centims. anterior to the point at which it joins the mid-ventral line."

"The posterior edge of the isolated field of reply passes from a point in the mid-ventral line very nearly 6 centims. above the umbilicus, and runs outwards, slightly ascending, and crossing the edge of the cage of the thorax at the tip of the 9th costal cartilage. It crosses the line of the deepest vertical of the cage of the thorax on the 10th rib, and making a gradual ascent in its course reaches the mid-dorsal line about 2·8 centims. behind the anterior edge of the field."

"The distance of the posterior border of the upper field of reply (IVth thoracic) from the anterior edge of the isolated field of reply is greatest (2 centims.) near the mid-ventral line, least somewhat on the ventral side of a vertical drawn upward from the anterior superior spine of the iliac crest, and is there about 5 centims. The distance of the posterior border of the isolated field of reply from the anterior edge of the lower field of reply (the Xth thoracic root-field) is greatest close to the mid-venter and is there 2 centims., and is least in the vertical drawn upward from the anterior superior spine of the ilium, where it is only ·4 centim."

"The dorsal border of the isolated field of reply comes quite up to the lip of the incision made at the commencement of the operation, that is to say, laps across the mid-dorsal line by at least 5 millims. The dorsal border measures 2·6 centims. The ventral border of the field measures about 3 centims. but has rounded angles, it laps across the mid-ventral line by more than ·5 centim. at places."

"The isolated field of reply is a band stretching from mid-dorsal line to mid-ventral line, its narrowest part is at the dorsal edge, and its widest part is about the middle of the lateral aspect of the chest where its measurement is 3·8 centims."

At autopsy the pairs of ribs were twelve in number.

VIIth Thoracic.

Experiment.—*M. rhesus.* Male; strong. 27.11.1890.

Measures :—

From umbilicus to pubic crest	9·3 centims.
,, nipple to pubes	22·8 ,,
,, xiphoid to umbilicus	10 ,,

At 12.15, the VIIIth, IXth, Xth, and XIIth thoracic, and the Ist, IInd, IIIrd, IVth, Vth, VIth, and VIIth lumbar nerve-roots divided on the right side. At 5.45 the final delimitation of the posterior border of the cutaneous field of the VIIth thoracic root.

"The lower limit of the upper field of reply crosses from the mid-dorsal line over the lateral aspect of the chest about 2·5 centims. above the lowest point of the thoracic cage. It leaves the thorax just above the tip of the 9th rib, and strikes the mid-ventral line half-way between the ensiform cartilage and the umbilicus, *i.e.*, 5·4 centims. above the umbilicus."

VIIth Thoracic.

Experiment.—*M. rhesus.* Female; strong. 22.10.1891.

Measures :—

From suprasternal notch to infrasternal	9 centims.
,, pubes to infrasternal notch . . .	18·5 ,,
,, ,, ,, . . .	18 ,,

At 11.15 the lowest five cervical and the Ist, IInd, IIIrd, Vth, and VIth thoracic roots of the right side severed. Anterior edge of skin-field of VIIth thoracic finally examined at 6.10.

"The upper border of the lower field of æsthesia starts from the mid-dorsal line 2·5 centims. below the lower edge of the cutaneous isolated field (proved by *post-mortem* dissection to be the IVth thoracic) runs outward more horizontally than does that, and very accurately parallel with the upper edge of the isolated field. Under the inferior angle of the scapula the edge is only 8 millims. below the lower edge of (IVth thoracic) isolated field, and runs parallel with that to the mid-axillary line, where it slopes downward more and reaches the mid-sternum nearly 2 centims. below it at the level of the upper edge of the 7th costal cartilage at its sternal end. This upper limit of the lower field of æsthesia is at a lateral distance of one inch from the mid-dorsal line on a level with the angle of rib 8, and runs almost horizontally toward the spine. The tip of the spinous process of the 8th thoracic vertebra is just about on the same horizontal level, or perhaps a trifle lower than the angle of the 8th rib."

"In the dorsal portions of the lower and the isolated cutaneous fields, the anterior border runs more horizontally than does the posterior border of the isolated field. In the ventral portions of the fields the anterior border descends, *i.e.*, slants off posteriorly more rapidly than does the posterior of the isolated field."

Ribs, twelve in number each side.

VIIth Thoracic.

Experiment.—*M. sinicus.* Female; young. 26.8.91. Plate 42, fig. 2.

Measured :—

Acromion to tip of 3rd digit	23 centims.
Suprasternal notch to pubic crest	21·5 ,,
,, ,, nipple	4 ,,
,, ,, infrasternal notch . .	7·5 ,,

The posterior divisions of the IVth, Vth, VIth, VIIth, VIIIth cervical, the Ist, IInd, IVth, Vth, and VIth thoracic roots of the right side divided (in the vertebral canal) at 8.50. At 4.30 the cutaneous field of the VIIth thoracic delimited at its anterior border.

"The edge of this field agrees closely with the edge found on the 8th of this month in *M. rhesus.* It sweeps below the nipple (2·75 centims. below) from a point on the mid-sternum a little more than half-way from the nipple to the xiphoid notch."

Post-mortem examination showed twelve pairs of ribs.

VIIIth Thoracic.

Experiment.—*M. sinicus.* Male, young. Testes undescended. 28.5.91.

Measurements :—

Suprasternal notch to infrasternal notch . . .	8·8 centims.
,, ,, pubic crest	27 ,,
Acromion to tip of 3rd digit	29 ,,
Nipple to infrasternal notch	4 ,,
,, suprasternal notch	4·5 ,,

At 8·50 the VIIIth cervical and the Ist, IInd, IVth, Vth, VIth, and VIIth thoracic roots of the righ side severed. At 6.15 the anterior border of the cutaneous field of the VIIIth thoracic finally ascertained.

"The anterior edge of the lower field of reply starts from a good 1·5 centim. of crossed overlap on the sternum, at a level about ·5 centim. above the sub-thoracic notch, and then slopes upward to cross the mammillary line 3 centims. below the mammilla; it curves upward and then boldly descends behind the mid-axillary line so as to cross the 7th rib at a level rather below that of the junction with the ventral crossed overlap. It then runs horizontally back to the mid-dorsal line, with a dip of ·75 centim., half-way between the posterior axillary line and the mid-dorsal line."

On *post-mortem* examination, thirteen ribs were found on each side.

VIIIth Thoracic.

Experiment.—*M. rhesus.* Female. 8.6.1891.

Dimensions:—

Middle of Poupart's ligament to nipple	19·5 centims.
" " " edge of tibial head	10·5 "

At 8.50 A.M. the roots of the IXth and Xth thoracic nerves of the right side severed in the spinal canal. At 1.15 the posterior border of the cutaneous field of the VIIIth thoracic root determined.

"The lower edge of the upper field of reply slopes from the mid-dorsal line on a level with the inferior angle of the scapula (the arm raised above level of shoulder) and runs downwards and forwards about 1 centim. below the scapula; it passes over the ventral edge of the cage of the thorax above the point of the 10th rib, and about 10·5 centims. above the middle of Poupart's ligament. It reaches the ventral crossed overlap 4·6 centims. above the umbilicus."

IXth Thoracic.

Experiment.—*M. rhesus.* Female. 6.4.1891.

Measurements:—

Nipple to sternal notch	4 centims.
Ankle to knee	13 "
Poupart's ligament to knee	11·5 "

At 10.30 the IVth, Vth, VIIth and VIIIth thoracic nerve roots of the right side divided in the spinal canal. At 4.30 the anterior border of the IXth thoracic root-field ascertained.

"The upper edge of the lower field of reply runs from the mid-dorsal line about ·5 centim. below the lower edge of the isolated field. It runs at first almost horizontally, and then slopes downward more obliquely than the edge of the field above it. It passes below the scapula (arm horizontally extended) and reaches the ventral crosslap about 1·5 centims. below the point at which the lower edge in this isolated field reaches it, attaining the mid-ventral line about 6 centims. above the umbilicus of the individual."

IXth Thoracic.

Experiment.—*M. rhesus.* Female. 17.11.1890.

Measures 8·5 centims. from umbilicus to crest of pubes.

The Xth and XIth thoracic and the first three lumbar roots of the right side divided at 10.50. Final determination of posterior border of IXth thoracic skin field at 5.40.

"The lower edge of the upper field of reply starts from the mid-dorsal line about 1·2 centim. above the lowest point of the cage of the thorax, *i.e.*, tip of 12th rib. It passes over the last rib 1 centim. from its end, and about ·7 centim. above the lowest point of the cage of the thorax. Running almost horizontally for a couple of centimetres, it leaves the lateral aspect of the cage of the thorax between the tips of the 10th and 11th ribs. Up to this place, it has only descended slightly, that is to say, about 1·2 centim. from its level at the mid-dorsal line, but, from this point onwards, it slopes down rather more obliquely to reach the mid-ventral line 2·4 centims. above the umbilicus."

On *post-mortem* examination the pairs of ribs were ascertained to be twelve.

Xth Thoracic.

Experiment.—*M. rhesus.* Male, young. 24.11.1890. Plate 44, fig. 7.

Measurements :—

Pubes to infrasternal notch	17 centims.
Vertical distance from nipple to anterior superior spine .	14 ,,

At 9.10 the two lowest thoracic and the IInd, IIIrd, IVth, VIth, VIIth, VIIIth, IXth, and Xth subthoracic roots of the right side severed. At 6.30 the posterior border of the Xth thoracic root finally ascertained.

"The lower edge of the upper field of reply runs obliquely downward and outward from the mid-dorsal line, passing about ·5 centim. below the point of the 12th rib, and keeping more horizontal from that point halfway to the mid-ventral line. It meets the mid-ventral line about 2 centims. above the umbilicus."

At autopsy the pairs of ribs were found to be twelve in number.

Xth Thoracic.

Experiment.—*M. rhesus.* Female; young. 17.12.1890.

Dimensions :—

Umbilicus to pubes	8·5 centims.
Nipple to pubes	21·5 ,,

At 11.30 the Vth, VIth, VIIIth and IXth thoracic roots of the right severed. The anterior border of the cutaneous field of the Xth thoracic root finally determined at 7.20.

"The upper limit of the lower field of reply is traceable by a line which may be followed from the mid-dorsal line about 7·5 centims. above the level of the umbilicus, and barely 5 centims. below the point at which the lower edge of the upper field of reply meets the mid-dorsal line" (*i.e.*, gap between IVth thoracic and Xth thoracic is barely 5 centims. wide). "The line, from that point, slopes downward and outwards," descending at an angle of about 75° with the long axis of the trunk. "Exhibiting but slight sinuosity, it slopes to the mid-ventral line, which it attains 4·5 centims. above the umbilicus, and 7 centims. below the point at which the lower edge of the upper field of reply attains it" (posterior border of IVth thoracic root field).

The number of ribs was found at the autopsy to be normal.

Xth Thoracic.

Experiment.—*M. rhesus.* Male. 15.10.1890.

Measurements :—

From top of symphysis to xiphoid is	17 centims.
From the tip of the 12th rib to the anterior superior spine	5·5 ,,

At 9·40 the XIth and XIIth thoracic and the Ist post-thoracic roots of the right side severed. At 6 P.M. the posterior border of the cutaneous field of the Xth thoracic finally determined.

"The lower edge of the upper field of reply starts from the mid-dorsal line on a level with the lowest part of the cage of the thorax, *i.e.*, nearly 6 centims. above the level of the anterior superior spinous process. It descends obliquely outward to the line of the transverse process, and from that line to 1·2 centim. below the tip of the 12th rib, and about 1 centim. below the lowest edge of the cage of the thorax, sweeps almost horizontally round the abdomen to 3 centims. from the mid-ventral line. At that distance from the mid-ventral line, it again descends more rapidly to reach the mid-ventral line about 1·2 centim. above the umbilicus, *i.e.*, about 10 centims. above the symphysis pubis."

Ribs and lumbar vertebræ normal in number.

XIth Thoracic.

Experiment.—*M. rhesus.* Female. 8.6.1891.

Measured :—

Middle of POUPART'S ligament to nipple	19·5 centims.
„ „ „ „ inner head of tibia	10·5 „

The roots of the IXth and Xth thoracic nerves divided on the right side at 8.50 A.M. At 12.40 the anterior border of the XIth thoracic root field determined.

"The upper edge of the lower field of reply starts from the mid-dorsal line about 1·5 centim. below the lower edge of the upper field of reply. It may be described as a line sloping downward slightly as it runs outward to about the mid-lateral line of the trunk. From that point it slopes more abruptly downward and reaches the ventral crossed overlap about 2 centims. above the umbilicus, about 2·5 centims. below the lower edge of the upper field of reply."

Ribs normal in number.

XIth Thoracic.

Experiment.—*M. rhesus.* Female; young. 10.10.1890.

Measurements :—

Anterior superior spine of ilium to tip of last rib . . .	5·5 centims.
Umbilicus to crest of pubes	7·5 „

At 11 o'clock the XIIth thoracic and the Ist and IInd, the IVth, Vth, VIth, VIIth, and VIIIth post-thoracic roots of the right side severed. At 6 o'clock the posterior border of the cutaneous field of the XIth thoracic root finally determined.

"The lower boundary of the upper field of reply starts from the mid-dorsal line on a level about 1·5 centim. above the umbilical level. It descends thence in a curve, which is convex upward, to a point on a line 3 centims. from the mid-dorsal line, about 1 centim. below the level of the starting point. Running horizontally for the next 2 centims. it turns upward and comes to lie about 2·8 centims. below the apex of the 12th rib. Thence it sweeps downward gently so that 2 centims. from the mid-ventral line it is 1 centim. below the level of the umbilicus, and strikes the mid-ventral line 2·8 centims. below the umbilicus."

This is a higher position of the border than in the two other estimations of it, and may be due to individual variation, as the plexus on dissection was markedly post-fixed. But against that explanation, accounting for the entire discrepancy, is the fact that the field for the IIIrd lumbar root, which was determined in the same individual, did not differ much from the estimations in other individuals. It is probable that the full limits of the field of reply were curtailed by the depth of the anæsthesia and the exhaustion towards the end of the experiment.

Ribs, twelve in number each side.

XIIth Thoracic.

Experiment.—*M. rhesus.* Female; older. 12.11.1890.

Dimensions given p. 702.

At 11 o'clock the two highest and the IVth, Vth, VIth, VIIth, VIIIth, Xth, and XIth post-thoracic roots of the right side severed. At 6.50 the lower limit (posterior border) of the field of the XIIth thoracic root finally determined.

"The lower limit of the upper field of reply is traced as a line starting from the mid-dorsal line

·8 centim. below the level of the umbilicus, about 3·5 centims. below the lowest point of the cage of the thorax. After sloping very slightly for the dorsal 3 centims. of its course, it turns more obliquely downward, presenting a slight convexity upward. It then curves inward toward the mid-ventral line, and meets that line at a point 4 centims. below the umbilicus. It is separated from the upper of the two isolated fields of reply (IIIrd lumbar) by about 1·5 centim. at the mid-dorsal line. At 3 centims. lateral from the mid-dorsal line the interval is only 1·1 centim., but near the mid-ventral line is greater, amounting where greatest to 4·5 centims."

XIIth Thoracic.

Experiment.—*M. rhesus.* Female. 17.11.90. Plate 45, fig. 8.

Measurements on p. 702.

The Xth and XIth thoracic, and the highest three lumbar roots of the right side divided at 10.50. Final determination of the isolated field of the XIIth thoracic at 6.30.

" The anterior edge of the isolated field of reply meets the mid-dorsal line 1 centim. behind the point at which the posterior edge of the upper field of reply (IXth thoracic) meets it. It passes just over the tip of the last rib, sloping downwards for a considerable distance, and then upward for a shorter distance, in order to do so. From the end of the last rib it runs downward and inward, descending somewhat more rapidly toward the mid-ventral line, which it reaches about ·8 centim. above the umbilicus."

" The posterior edge of the isolated skin field starts from the mid-dorsal line about on the horizontal level of the umbilicus, 3 centims. below the point at which the anterior edge meets the mid-dorsal line. Descending rather rapidly for the first 2·5 centims. of its outward course, it turns in a horizontal direction above the anterior superior iliac spine, at a distance of 1 centim. above it. It then descends again more rapidly, later less rapidly, to strike the mid-ventral line, 4·2 centims. below the umbilicus, *i.e.*, 4·5 centims. above the crest of the pubes."

" The dorsal border measures 3 centims. and laps across the mid-dorsal line for at least ·4 centim. The ventral border measures nearly 4 centims., and laps across the mid-ventral line by at least ·8 centim. in some places."

" The field appears narrowest at the dorsal border of it; widest a short distance from the ventral border of it."

At autopsy ribs ascertained to be twelve in number each side.

" The isolated field of reply (XIIth thoracic) is separated from the upper field (IXth thoracic) by a space of 1·2 centim. behind; by a space of more than 2 centims. near the mid-ventral line."

XIIth Thoracic.

Experiment.—*M. rhesus.* Female; young. 19.11.90. Plate 44, fig. 6.

The posterior roots of the Ist, IInd, IIIrd, Vth, VIth, VIIth, VIIIth, and IXth post-thoracic spinal nerves of the right side severed at 11.25. The lower (posterior) border of the skin field of the XIIth thoracic marked out at 3.30 finally.

" The border corresponds closely with that found for the XIIth dorsal, the last experiment. It slopes downward more steeply in front than behind. There seems a greater ventral crossed overlap than in the last experiment."

Ribs twelve in number each side.

XIth and XIIth Thoracic compared.

Experiment.—*M. rhesus.* Female. 7.1.91.

The posterior roots of the Ist and IInd, the IVth, Vth, VIth, VIIth, and VIIIth post-thoracic spinal roots of the right side divided at 11.40 A.M. At 1.50 the posterior root of the XIIth right thoracic also divided. Comparison of the posterior borders of the XIIth and XIth thoracic cutaneous fields.

"The two borders run fairly parallel, but slightly wider apart at the ventral crossed overlap. The distance between them certainly is not more than half the vertical depth of the XIIth thoracic field. Both reach the ventral crossed overlap below the umbilicus. It is clear that the umbilicus must lie about the middle of the XIth thoracic skin field. The ventral crossed overlap barely amounts to a centimetre in width."

Ribs twelve in number each side.

XIth and XIIth compared.

Experiment.—*M. rhesus.* Female. 12.11.1890. Plate 45, fig. 11.

The posterior borders of the XIth and XIIth thoracic were compared at end of experiment on the IIIrd post-thoracic, and similar results obtained to the result above.

Ist Post-thoracic.

Experiment.—*M. rhesus.* Male; young. 31.10.1890.

The measurements were—

From anterior superior spine to tendo patellæ	18 centims.
,, xiphoid to pubes	16 ,,

At 9.50 A.M. the IInd, IIIrd, IVth, VIth, VIIth, VIIIth, and IXth post-thoracic roots of the right side severed; at 3.30 the posterior border of the cutaneous field of the Ist lumbar finally determined.

"The lower edge of the upper field of reply starts from the mid-dorsal line, about 3·5 centims. above the level of the highest point of the iliac crest, or probably just below the lower edge of the spinous process of the 3rd vertebra, in front of the sacrum (Vth lumbar). It slants outward from the mid-dorsal line, and, on reaching the line of the tips of the transverse processes, it curves downward more obliquely to the anterior superior angle of the crista ilii (reaching the level of the crista just medial to the anterior superior spine. It sweeps forward and downward to the inguinal fold, and then turns a little way down the thigh, and stops to pass inward, parallel and above the inguinal fold across toward the horizontal limb of the pubes, which it reaches about over the medial edge of the obturator foramen. On the pubes it approaches the isolated field of reply, but it is doubtful whether they really join" (Ist lumbar and Vth lumbar).

Ist Post-thoracic.

Experiment.—*M. rhesus.* Male; young. 24.11.1890. Plate 44, fig. 7.

Measured—

Pubes to infrasternal notch	17 centims.
Anterior superior spine to nipple	14 ,,

At 9 the two lowest thoracic roots and the IInd, IIIrd, IVth, VIth, VIIth, VIIIth, IXth, and Xth spinal roots of the right side divided. At 6·5 the skin field of the Ist lumbar finally delimited.

"The anterior edge of the upper of the isolated skin field of reply slants outward and slightly downward from the mid-dorsal line to a point 2·7 centims. below the tip of the last rib, on a line from the tip of the last rib to the anterior superior iliac spine, the length of the line being 6·5 centims. The line then slopes more rapidly downward, and strikes the mid-ventral line about 1 centim. below the umbilicus."

"The posterior edge of this isolated field of reply runs from the mid-dorsum, at a point just anterior to the level of the anterior superior iliac spine, and along a line close above the iliac crest. It meets the iliac crest about 1 centim. behind the anterior superior spine, passes 1 centim. below that spine, and curves downward and ventralward to a few millimetres below the spine of the pubes; on the rectus abdominis fold it descends a short way, and returns upwards on itself. About midway between the anterior superior spine of the ilium and the spine of the pubes the line descends, making a convex sweep downward, so as to form a shallow tongue pointed towards the knee."

The number of ribs was twelve pairs.

"The dorsal border measures 3·5 centims. The ventral border measures nearly 8 centims. The greatest vertical depth of the field is 8·5 centims."

Ist Post-thoracic.

Experiment.—*M. rhesus.* Female. 20.2.1891.

Dimensions, see Experiment.

At 10.50 the posterior roots of the IInd, IIIrd, IVth, Vth, VIIth, and VIIIth post-thoracic nerves of the right side divided. At 4 o'clock the final estimation of the field belonging to the posterior border of the Ist post-thoracic completely found.

"The lower edge of the upper field of reply passes from a point near the mid-ventral line, on the front of the pubes, and ascends, passing outwards along the fold of the groin, thrusting a little projection downward on the top of SCARPA's triangle. It reaches a point in the line of the anterior superior iliac spine about ·5 centim. below it, and then runs backward more horizontally to reach the mid-dorsal line, somewhat above the level of the anterior superior spine."

Ist Post-thoracic.

Experiment.—*M. rhesus.* Female. 22.12.1890.

Measured :—

Umbilicus to pubes	8 centims.
Anterior superior spine of ilium to nipple	7·5 ,,

At 9.40 the IInd, IIIrd, IVth, VIth, VIIth, VIIIth, IXth, and Xth spinal roots of the right side divided intraspinally. At 2.5 the posterior border of the field of cutaneous distribution of the Ist lumbar finally delimited.

"The lower edge of the upper field of reply runs from the mid-dorsal line at a level about 1 centim. higher than that of the anterior superior spine of the ilium. It slopes downwards and forwards, passing over the anterior superior spine about ·4 centim. above it. It slopes downward above, but parallel with the inguinal fold. It meets the mid-ventral line decidedly lower than mid-way between the pubes and the umbilicus." "There is a slight spur from this upper field pushed out toward the limb in front of the anterior superior spinous process of the ilium."

Twelve ribs each side.

IInd Post-thoracic.

Experiment.—*M. rhesus.* Male. 27.10.1890.

Measurements :—

Top of symphysis to xiphoid	17 centims.
Tip of 12th rib to anterior superior spine	5·5 ,,

At 9.40 the two lowest thoracic and the Ist lumbar and the IIIrd, IVth, Vth, and VIth lumbar roots of the right side severed. At 7.30 the limits of the field of cutaneous distribution of the IInd lumbar root ascertained finally.

"The upper edge of the isolated field of reply stretches from the mid-dorsal line 3 centims. in front of the level of the crista ilii, and descends to 2 centims. above the level of the crest in the line of the anterior superior spinous process. From that position it slopes downward and inward at some distance above the inguinal fold with a slightly sinuous course to a point on the mid-ventral line, just higher than midway between the top of the symphysis pubis and the umbilical scar."

"The lower edge of the isolated field of reply stretches from the mid-dorsal line at a point about 1·5 centim. below the level of the anterior superior spinous process of the ilium, and then slopes, at first less, later more steeply outwards and downward, so that it crosses the vertical dropped from the anterior superior spinous process about 4·2 centims. below the spinous process. It follows a course down the sartorio-rectus fold, gradually turning over the crest of that toward the anterior aspect of the thigh, and descends the thigh as low as the apex of SCARPA'S triangle, but rather to the outer side of that. It then recurves on its course, enclosing a tongue-shaped flap, and sweeps inward and upward to the middle of the front of the symphysis."

"The shape of the isolated field of reply may be described as broadly strap-shaped, the wider end of the strap lying on the thigh."

IInd Post-thoracic.

Experiment.—*M. rhesus.* Female. 13.2.1891.

The IIIrd, IVth, Vth, VIIth, and VIIIth post-thoracic roots of the right side cut at 11.20. At 1.45 the lower edge of the upper field of reply, *i.e.*, the posterior border of the IInd lumbar, was determined.

"The lower edge of the upper field of reply starts from near the mid-ventral line at the front of the pubes, and curves down the thigh on the extensor mass to about half-way between POUPART'S ligament and the knee. It turns upward then and runs above the hip to about 3 centims. below the anterior superior spinous process of the ilium, and reaches the mid-dorsal line somewhat higher, about 2 centims. in front of the anterior border of the gluteal field of reply."

Ribs, the normal twelve on each side.

Ist and IInd Post-thoracic compared.

Experiment.—*M. rhesus.* Male. 3.11.1890.

Measurements :—See p. 726.

The posterior border of the cutaneous field of the Ist lumbar compared with that of the IInd lumbar.

At 9.40 the IIIrd and IVth, the VIth, VIIth, VIIIth, and IXth post-thoracic roots of the right side severed. The posterior border of the IInd lumbar was delimited at 12.30, and then the IInd lumbar root was severed, and at 4.50 the posterior border of the cutaneous field of the Ist lumbar was finally determined.

"The lower border of the upper field of reply runs from a point in the mid-dorsal line about 3 centims. below the level of the anterior superior spinous process of the ilium outward about ·8 centim. above the inner angle of the iliac crest, crossing over the crest about 1·2 centim. ventral to the inner angle, and meeting the outer edge of the crest about 1·5 centim. below the anterior superior spine. Thence descending along the crest of the sartorio-rectus fold to 1 centim. below the level of the line from the top of the great trochanter to the top of the symphysis. It curves from that point inwards, and then retreats upwards before again descending. It meets the isolated field of reply" (Vth lumbar) "and then, separating from it again, attains the mid-ventral line on the symphysis pubis." "The place at which it appears to meet the isolated field of reply is about 1 centim. to the median side of the apex of SCARPA'S triangle."

"The lower edge of the upper field of reply has retreated to a various extent at various portions of it. It now represents a nerve-root one segment higher than that which it did previously. The limit now runs from the mid-line of the back 1·5 centim. higher than it did before, *i.e.*, about 1·5 centim. below the level of the anterior superior spinous process. It slants in an outward direction as before, but more nearly horizontally now, until about 3 centims. distant from the mid-dorsal line, when it turns downward obliquely to pass about 1 centim. or less behind and below the anterior superior spine of the ilium, and sweeps forward following the line of the posterior border of the previous limit" (IInd lumbar), "but about 15 millims. above it. It keeps parallel to the previous line for a short distance, and then turns downward and inward, with a shallow projection convex towards the thigh, along but soon above the inguinal fold. About 1 centim. above the root of the penis it passes on to the front of the pubes."

IInd Post-thoracic.

Experiment.—*M. rhesus.* Male. 19.10.1890.

Measurements not taken.

At 10.10 the IIIrd, IVth, Vth, VIIth, and VIIIth roots of the right post-thoracic nerves divided in the spinal canal: at 4.20 the posterior border of the cutaneous field of the IInd lumbar ascertained.

"The lower edge of the upper field of reply may be traced by a line starting from a point near the mid-venter above the root of the penis, thence following roughly the inner horizontal half of POUPART'S ligament and then almost suddenly descending the thigh on SCARPA'S triangle, tending outward gradually toward the crest of the extensor mass rather more than halfway down the thigh. From that, its lowest level, it turns upward on the rectus and sartorius to run about ·6 centim. below the anterior superior spine, and thence inclines gradually upwards and inwards until it meets the mid-dorsal line."

Twelve ribs on each side.

IIIrd Post-thoracic.

Experiment.—*M. rhesus.* Female; young. 19.5.1891.

Dimensions not measured.

At 10.15 the IVth, Vth, VIth, VIIth, VIIIth, IXth, and XIth and XIIth post-thoracic roots severed on the right side. At 5.20 the upper field of reply delimited below (found to consist entirely of the posterior border of the IIIrd lumbar).

"The lower edge of the upper field of reply is traced from the mid-dorsum at a level 4 centims. below the level of the anterior superior spine of the ilium, and slopes downward and outward to enter the external aspect of the thigh about 5·5 centims. below the anterior superior spine of the ilium. It descends the thigh, encroaching more and more on the anterior aspect as it does so, and about 1·5 centims. above the upper border of the patella turns inward, still sloping so as to nearly reach the inner angle of the upper border of the patella. It then sweeps inwards, and increasing in steepness ascends the inner side of the anterior aspect of the thigh on the anterior border of the adductor fold, and finally reaches the front of the pubes near the lower edge of the symphysis."

Whether this edge is entirely composed of the field of the IIIrd lumbar or not will be discussed later.

Twelve pairs of ribs.

IIIrd Post-thoracic.

Experiment.—*M. rhesus.* Female; older. 12.11.1890. Plate 45, fig. 11.

Dimensions measured were—

Anterior superior spine to patella . .	17·5	centims.
,, ,, ,, ankle . .	30	,,
Pubes to umbilicus	9	,,

The two highest and the IVth, Vth, VIth, VIIth, VIIIth, Xth, and XIth post-thoracic roots of the right side severed at 11 o'clock. At 6 o'clock the upper of the two isolated skin fields (that of the IIIrd lumbar root) finally delimited.

"The anterior edge (upper edge) of the isolated field of reply has been traced from the mid-dorsal line at a point 2 centims. in front of a line joining the highest points of the crests of the right and left ilia. Sloping steeply down at first it soon afterwards curves more outward, and at a point 4 centims. from the mid-line is running almost horizontally at a distance of 5·5 centims. below the tip of the last rib. Thence it turns steeply downward again to a point about 1 centim. anterior to the anterior superior spine, whence it again descends, giving a figure curved convexly upward to reach POUPART'S ligament just inside the middle point of the ligament. It follows the line of the inguinal fold to the spine of the pubes, reaching the mid-ventral line 3 centims. above the ventral end of the posterior border of the field."

"The lower edge of this field of reply starts from the mid-dorsal line about 2 centims. below (posterior to) the upper edge, and about 1·6 centim. in front of the anterior edge of the lower isolated field of reply (IXth post-thoracic). It runs outward and downward parallel to the anterior edge of the lower isolated field (IXth post-thoracic) to a point about ·4 centim. above the top of the great trochanter. Thence the line descends less steeply over the external anterior aspect of the thigh to about 1 centim. above the patella; it reaches its lowest point somewhat less than 1 centim. internal to the inner edge of the quadriceps extensor tendon above the patella. It then ascends on the intero-anterior aspect of the thigh, passing over the fold marking the prominent edge of the adductor group at the junction of the lowest and middle thirds of the thigh. It runs parallel to the pubic fold, but ·8 centim. anterior to the crest of that fold, and reaches the mid-ventral line ·5 centim. above the junction of the right and left pubic folds."

Twelve ribs on each side.

IIIrd Post-thoracic.

Experiment.—*M. rhesus.* Female. 25.10.1890.

Measurements not taken.

The posterior divisions of the IVth, Vth, VIIth, VIIIth, and IXth post-thoracic spinal nerves of the right side divided in the vertebral canal at 11.15. At 7.25 the field of cutaneous distribution of the IIIrd lumbar (its posterior boundary) was examined finally. The examination confirmed previous ones, but did not give a field that tallied with observations on other individuals.

"The posterior edge of the upper field of reply lies about 1 centim. above the anterior edge of the lower field. It passes down the outer side of the thigh and then turns inward across the front of the thigh at a level rather above half-way between groin and knee; it soon ascends again, forming a narrow peak on the front of the thigh and sloping then less obliquely upwards, reaches the inner edge of the thigh close to the genital fold."

This lower limit for the field of the IIIrd lumbar is unusually low; it does not appear an error of experiment, because it was found later that the areas of the VIth and Xth post-thoracic nerves were all of them displaced in a similar sense in this experiment, and subsequent dissection revealed a very post-fixed lumbo-sacral plexus. The ribs and lumbar vertebræ were counted carefully and there was no abnormality in their number.

IIIrd Post-thoracic.

Experiment.—*M. rhesus.* Female; young. 10.11.1890.

Measurements not taken.

At 11 A.M. the lowest thoracic and the two highest lumbar, and the IVth, Vth, VIth, VIIth, and VIIIth post-thoracic roots of the right side severed. At 5.5 the area of cutaneous distribution of the IIIrd lumbar delimited.

"The upper border of the isolated field of reply starts from the mid-dorsum 3·5 centims. in front of the point at which the lower border of the field meets the mid-dorsum, and about 2 centims. above a line joining the highest points of the crests of the right and left ilia. Sloping steeply down at first it soon curves more outward, and at a point 4 centims. from the mid-dorsum runs almost horizontally at a distance of 5·5 centims. below the tip of the last rib. Thence it slopes steeply downward again to a point 1 centim. anterior to the anterior superior spine of the ilium, whence it descends with a border convexly curved upward to each POUPART'S ligament just inside its middle point. It follows the inguinal fold to the spine of the pubes, reaching the mid-ventral line 3 centims. above the ventral extremity of the posterior border of the field."

"The posterior border starts from the mid-dorsal line 1·6 centim. in front of the anterior border of the posterior field of reply." (Root IXth post-thoracic.) "It passes downward and outward parallel to that border to a point ·3 centim. above the top of the great trochanter. Thence the limit descends less steeply over the extero-anterior aspect of the thigh to 1 centim. above the patella; it reaches, however, its lowest point somewhat less than 1 centim. above the inner border of the quadriceps extensor tendon above the patella. It then ascends on the internal anterior aspect of the thigh passing over the fold marking the edge of the adductor group, and about the level of junction of the middle third with the lowest third of the thigh. It runs parallel with the pubic fold, but about ·8 centim. anterior to the crest of that fold, and reaches the mid-ventral line ·5 centim. anterior to the junction of the right and left pubic folds.

"The dorsal border is 3·5 centims. long and laps at least ·4 centim. across the mid-dorsal line." As to the size and position of that portion of the edge of the field that must be considered the ventral border, later considerations will be urged to settle that point.

The ribs are twelve in number.

IVth Post-thoracic.

Experiment.—*M. rhesus.* Female; small. 17.11.1890. Plate 44, fig. 8.

Measurements, on p. 702.

The Xth and XIth thoracic and the highest three lumbar roots of the right side severed at 10.50. Final determination of the anterior border of the IVth lumbar root at 7.10.

"The anterior edge of the lower field of reply starts from the mid-dorsal line ·2 centim. above the level of the crest of the ilium, descends to that crest, meeting it 1·2 centim. dorsal to the anterior superior spinous process; it crosses to 1 centim. below the anterior superior spine, running close below POUPART'S ligament in its outer half, and turns down the limb just on the crest of the prominence of the rectus femoris; it follows that direction to as far as a point rather more than 3 centims. below the inguinal flexure, and then turning inwards soon doubles back across SCARPA'S triangle to 1·4 centim. below POUPART'S ligament. Then again it sweeps inward, and running for a short distance almost horizontally, approaches the mid-ventral line, not, however, to reach it, for turning downward about 1 centim. away from the mid-ventral line it strikes the genital fold 1·5 centim. from the angle of the notch."

Ribs twelve in number each side.

IVth Post-thoracic.

Experiment.—*M. rhesus.* Female; young. 19.11.1890. Plate 44, fig. 6.

Measures—

From anterior superior iliac spine to spine of pubes . .	10·5 centims.
,, ,, ,, ,, tip of 3rd digit . .	38 ,,

At 12.15 the posterior divisions of the Xth and XIth thoracic, and the highest three lumbar, and the

Vth, VIth, VIIth, VIIIth, and IXth post-thoracic roots of the right side severed. At 4.30 the area of distribution of the IVth lumbar root determined finally.

"The isolated field of reply is a broad flag-shaped band extending ventrally from a relatively narrow attachment to the mid-dorsal line. The upper border of the field is deeply notched; the lower border passes below the knee obliquely. The limit of the area may be traced thus from the mid-dorsal line. Starting at a point in the mid-dorsal line distinctly below the level of the level of the umbilicus, it runs outwards from the middle with a gradually increasing downward slope to a point about 1 centim. below the anterior superior spine of the iliac crest, and then follows the fold caused by the rectus muscle and sartorious, somewhat to the medial side of that fold into the front of the thigh. Thence it returns on itself towards POUPART'S ligament for about 2 centims., and then once more curves inward and downward, lying on the front of the pubes but a full centimetre from the mid-ventral line. It then courses down the inner border of the thigh and leg behind the anterior edge of the gracilis fold, and over the medial belly of the gastrocnemius to reach the junction of the middle and lowest thirds of the leg on the postero-internal aspect of the leg; in this specimen 3 centims. above the point of the heel. Thence the line sweeps boldly round and forward, and turns upward obliquely over the skin, passing about 2·5 centims. below the patellar tendon and over the head of the fibula to reach the outer aspect of the thigh and slope across its anterior half, reaching the middle of the outer aspect about halfway up the thigh. It then ascends in a direction parallel with the long axis of the limb, and crosses a vertical dropped from the anterior superior spine about 7 centims. below that spine; finally it runs, ascending less sharply, to the mid-dorsal line, which it reaches 5 centims. below the point at which the anterior border of the field reaches it."

"The circumference of the thigh in its upper third being 15 centims., just about $7\frac{1}{2}$ (one-half) is supplied by this root field, and that half reaches from the middle of the outer aspect of the thigh to the inner edge of the thigh."

At the autopsy it was ascertained that the number of ribs and lumbar vertebræ was normal.

Photograph. Plate 44, fig. 6.

IVth and IIIrd Post-thoracic compared.

Experiment.—*M. rhesus.* Female. 26.9.1890.

Measurements not taken.

The posterior roots of the Vth, VIth, VIIth, IXth, and Xth post-thoracic nerves of the right side divided in the spinal canal at 9.10 A.M. Later the IVth post-thoracic root divided. Portion of the lower edge of the IVth lumbar, later the lower edge of the IIIrd lumbar examined.

"The anterior peak of the field of reply" (this peak is IVth lumbar) "descends over the front of the knee. It is bounded by a line that passes from a point on the outer aspect of the knee downwards and forwards over the crest of the tibia to the inner side of the skin, and then ascends on the inner face of the knee along the gracilis fold to a point about halfway up the inner border of the thigh."

After the last section:

"The lower edge of the upper field of reply starts from the mid-dorsal line above the root of the tail, and descends the outer side of the thigh over the hip gradually, in the lower half of the thigh, sloping inward over the extensor mass of the thigh to cross the front of the thigh above the patella and then turns upwards and inwards, meeting the inner edge of the thigh below the inguinal fold, and the outer border of the 'genital flap.'"

Vth Post-thoracic.

Experiment.—*M. rhesus.* Male; young. 29.10.1890.

Measurements, *vide supra.*

At 11.10 the VIth, VIIth, VIIIth, IXth, XIth, and XIIth post-thoracic roots of the right side severed. At 8 o'clock the posterior border of the combined fields of the IIIrd, IVth, and Vth post-thoracic roots delimited.

"The posterior edge of the upper field of reply starts from the mid-dorsal line about 4 centims. below the level of the crest of the ilium; turning downwards and outwards the line sweeps along the middle of the outer aspect of the thigh to behind and above the head of the fibula, and then follows the leg down to pass over the front of the ankle and on the dorsum pedis reach the space between the 2nd and 3rd metatarsal bones; it runs along the 2nd digit, recurves on the medial aspect of the terminal joint, reaches the web between hallux and 2nd digit, and courses along the middle of the prominence caused by the plantar muscles of the hallux, to ascend finally in the groove between the heel and the internal malleolus. It sweeps up the inner aspect of the leg over the inner head of the gastrocnemius, and then accurately along the internal *border* of the thigh and the genital crest and notch to the pubes."

The portions of this boundary which belong respectively to the IIIrd, IVth, and Vth roots will be discussed later; the portion belonging to the IIIrd is quite small.

Vth Post-thoracic.

Experiment.—*M. rhesus.* Male; young. 24.11.1890. Plate 44, fig. 7.

The two lowest thoracic nerve-roots and the IInd, IIIrd, IVth, VIth, VIIth, VIIIth, IXth, and Xth post-thoracic roots of the right side severed at 9.10.

The isolated area of the Vth lumbar delimited at 5.20.

"The edge of the isolated field of reply passes from a point 1 centim. from the mid-ventral line, halfway between the top of the symphysis pubis and the root of the penis downward and outward, sloping across the inner aspect of the thigh to the mid-quadriceps line, which it crosses above the top of the patella about 1 centim. above the patella, and then retires up the thigh again for about 2 centims. to gain the outer aspect of the thigh, and descend along the middle of it and the middle of the outer aspect of the knee over the peroneal group of muscles to the groove in front of the external malleolus; it enters the dorsum of the foot close to the outer side of the head of the astragalus, and somewhat distal to the tarso-metatarsal joint sweeps inwards, bisecting the first interdigital web. It curves round the hallux along the extreme limits of the aspect of the phalanges of the hallux, encroaching somewhat on the plantar surface along the inner edge, and passing distinctly on the plantar face of the foot about 1 centim. from the inner edge. It leaves the sole of the foot midway between calcaneum and internal malleolus to ascend on the inner edge of the tendo Achillis for 3 centims. before turning backward, always ascending, over the inner belly of the gastrocnemius to reach the fold of the inner hamstrings. The crest of that fold it gradually crosses, appearing on the prominence of the inner hamstring group at the postero-external aspect, about 2 centims. behind the scrotal flexure. It turns backward and inward so as to cross that fold again, and just in front of it, or on it, meets the point whence it started about 1 centim. from the ventral median line."

At the autopsy the ribs were found to be twelve in number.

Vth Post-thoracic.

Experiment.—*M. rhesus.* Male; young. 31.10.1890. Plate 46, fig. 12.

Measurement, *vide supra.*

The IInd, IIIrd, IVth, VIth, VIIth, VIIIth, and IXth post-thoracic roots of the right side severed at 9.50 A.M. The field of cutaneous distribution of the Vth lumbar explored and finally settled at 4.15 P.M.

"The edge of the isolated field of reply lies midway between the internal malleolus and the point of the heel; thence it passes along the sole of the foot along the line of the bones of the hallux, and upon the under surface of the hallux, tending toward its inner aspect, and, curving round the point of it, passes to the edge of the web between hallux and 2nd digit. After reaching the inner side of the dorsal aspect of the proximal joint of that digit, it runs up the middle of the dorsum of the foot to the front of the ankle, and ascends the leg. About one-third up the leg it sweeps round to the outer aspect of the leg, reaches the external head of the gastrocnemius, and passes behind the head of the fibula to the middle of the outer aspect of the thigh. It then returns across the front of the thigh, showing a notch at least 3 centims. deep on the rectus fold, and sweeps obliquely inwards to the front of the pubes, which it barely reaches, before it re-curves, and descends a little behind the actual inner edge of the thigh to the crest of the inner hamstring and inner head of the gastrocnemius, and running down the groove internal to the tendo Achillis, reaches again the hind part between the heel and the internal malleolus."

Ribs twelve in number on each side.

Vth Post-thoracic.

Experiment.—*M. rhesus.* Female; young. 22.12.1890.

At 9.40 A.M. the IInd, IIIrd, IVth, VIth, VIIth, VIIIth, IXth, and Xth post-thoracic roots severed.

At 4.15 the Vth post-thoracic field delimited finally.

"Starting from the outer edge of the nail of the hallux, it ascends along the lateral edge of the dorsal aspect of the hallux, the limiting line runs up the first intermetatarsal space near to the side of the first metatarsal bone, sweeping round the lateral edge of the first tarso-metatarsal joint, and then turning inward so as to strike the fold over the tibialis anticus tendon just distal to the astragalo-cuneiform joint. The line follows the tibialis anticus tendon upward, and at same time tends somewhat outward as well as upward, lying a little nearer the inner than the outer malleolus, and obliquely rising to cross the tibialis-peroneal septum three-quarters of an inch below the halfway point between knee and ankle. The line meets the outer edge of the gastrocnemius a little above that halfway point. It lies as far behind the head of the fibula as that head lies behind the anterior edge of the limb, and at level of point of knee lies at the junction of the third, and the most posterior quarter of the outer aspect. The distance from the great trochanter to the outer condyle being 10·5 centims., the limit of the area rises 4·5 centims. below the great trochanter, reaching that, its highest point, a little in front of the middle of the outer aspect of the thigh. Thence the line doubles back about 1 centim. behind the anterior border of the thigh to within 1·5 centim. of the patella, outer side. It then returns and crosses the mid-line of the anterior aspect of the thigh 3·5 centims. above the top of the patella. It crosses the inner sartorius fold 4·5 centims. below the middle point of POUPART'S ligament. Having reached its highest point just in front of the inner edge of the thigh, the line crosses the genital fold 1·5 centim. below the genital notch, and then immediately descends along the crest of the fold caused by the inner hamstring, and for 2·5 centims. down the protrusion over the inner head of the gastrocnemius to sweep on to inner aspect of leg, passing, as it does so, midway between the inner malleolus and the crest of the tendo Achillis ridge. It passes along the line of the tendon of the tibialis anticus, and onwards to the inner side of the sole just, but not far, on the hallucial prominence to the inner side of the proximal phalanx of the thumb. It there gains the point whence it was traced in this description, and reaches it by such a path as to include the medial, but not the lateral, part of the plantar aspect of the hallux."

"The circumference of the knee in the extended position of the limb being 14 centims., the Vth lumbar field occupies 10·5 centims. of the circumference. The shape of the area is, roughly speaking, a very elongated ace of hearts, the base of the heart turned toward the inguinal fold, and the notch in the base lying on the front of the thigh."

Ribs twelve in number on either side.

Vth Post-thoracic.

Experiment.—*M. rhesus.* Male. 29.12.1890.

Measured:—

Pubes to infrasternal notch	17 centims.
Vertical distance from nipple to anterior superior spine	14 ,,

At 9 A.M. the Xth, XIth, and XIIth thoracic, the IInd, IIIrd, IVth, VIth, VIIth, VIIIth, IXth, and Xth post-thoracic roots divided intraspinally.

At 5.30 the isolated field of reply examined for the last time.

"The field is roughly triangular with its base upon the thigh, its acutest angle at the apex of the hallux. It is limited by a line which has been made out along the inner edge of the thigh at the junction of the inner and posterior aspects of the limb. It descends thence along the leg, over inner head of gastrocnemius to groove behind internal malleolus. It runs over the plantar surface to the hallux, and turns over the web between hallux and the 2nd digit, to run along the dorsum (where the boundary is not easily determined) to the outer side of the front of the ankle-joint, close in front of the external malleolus. It ascends on the prominence caused by the peroneal group, and behind the head of the fibula and biceps tendon, then coming forward higher up and turning, obliquely ascending, over the extensor mass of the thigh. The line above the knee runs down a little toward the knee, then again pursues its oblique ascending course, and crosses the adductor group to attain the inner border of the thigh about half-way between hip and knee."

Vth Post-thoracic.

Experiment.—*M. rhesus.* Male. 3.11.1890.

Measurements:—

Symphysis to umbilicus	8·5 centims.
Anterior superior spine of ilium to ligamentum patellæ	18 ,,

The field of cutaneous distribution of the Vth lumbar root.

At 9.45 the IIIrd, IVth, VIth, VIIth, VIIIth, and IXth post-thoracic roots of the right side severed; later, the IInd also.

At 4.20 the cutaneous field of the Vth finally examined.

"The isolated area of reflex response is limited by a line that may be traced as follows:—Starting behind the head of the fibula, it descends the leg, and passes at about the mid-point of the anterior aspect of the ankle-joint on to the dorsum pedis; it reaches the inner side of the 2nd digit, curves round the root of that and runs up the inner part of the plantar surface to the inner face of the heel, ascends to the shin over the inner head of the gastrocnemius, thence along the inner edge of the thigh, nearly to the front of the pubes, but recurves before actually reaching that point. It then sweeps with a convexity upward, toward the knee on the extensor group of the thigh, and, leaving a bold notch, returns again toward the trunk on the outer aspect of the thigh, but does not retire beyond half-way up the thigh. Descending the outer face of the thigh toward the knee again, it passes to the point behind the fibular head from which it was originally traced."

Ribs, twelve on each side.

VIth Post-thoracic.

Experiment.—*M. rhesus.* Male. 27.1.1891. Plate 45, figs. 9 and 10.

Measurements not taken.

At 12.25 the posterior divisions of the Ist, IInd, IIIrd, IVth, Vth, VIIth, VIIIth, and IXth post-thoracic spinal nerves of the right side severed intraspinally.

Delimitation of the cutaneous field of the VIth post-thoracic root, at 7.40 P.M. completed.

"The isolated field of reply is an area completely detached from the mid-dorsal line and from the mid-ventral line. It occupies solely the skin of the limb proper. Its border is traceable by a line as follows. It lies 1 centim. to the outer side of the tendo patellæ, and from that spot descends, tending gradually toward the crest of the shin, and crossing inwards over that crest at a little below the junction of the middle and lowest thirds of the leg. It descends to within 2·5 centims. of the ankle-joint, and then returns upward sloping over the inner face of the shin to pass upward behind the fold of the gracilis. Just above the knee-joint it turns slantingly backwards over the inner hamstrings to about half-way up the posterior aspect of the thigh, passes almost in a straight line across to the outer (lateral) aspect of the thigh. This lateral aspect it turns across to a point about midway between the anterior and posterior borders of it, so that it reaches a point slightly above the mid-point of the lateral aspect of the thigh. At this point it turns abruptly at almost a right angle to descend the thigh near the external margin of the rectus femoris, and finally attains the outer side of the patella, and the point whence it was traced."

Normal number of ribs present on each side.

VIth Post-thoracic.

Experiment.—*M. rhesus.* Male. 19.10.1890.

Measurements not taken.

Delimitation of cutaneous field of VIth lumbar.

At 10.10 the IIIrd, IVth, Vth, VIIth, and VIIIth roots of the right post-thoracic nerves divided in the spinal canal.

At 4.50 the area of the isolated field of response completely delimited.

"The isolated field of reply is limited by a line traceable as follows:—Starting from the front of the shin bone, about one-third up the leg, it turns in an ascending direction obliquely inward to the edge of the calf muscles, and, along the inner edge of the gastrocnemius, follows behind the fold of the gracilis to run up above the ham to about the level at which the inner and outer hamstring groups converge at the top of the popliteal space. Having passed a little above and external to that point, the border suddenly retreats down the limb again, descending upon the head of the fibula to sweep above the peroneal group and reaches the anterior tibial group, and so gains the crest of the tibia and the point whence it was traced."

"On the outer edge of the foot, from the external malleolus to the base of the 5th digit, a small oval patch of extremely dull response exists; so dull that, in the earlier determinations, I questioned whether response was obtainable at all, and marked it provisionally as not giving reply. In the final delimitation, this area did seem to give a feeble response (extension of ankle), and I am not, therefore, clear about it."

The above line marked the upper boundary of the field of reply which included the whole of the distal end of the limb.

Normal number of ribs on each side.

VIth Post-thoracic.

Experiment.—*M. rhesus.* Female. 25.10.1890.

Delimitation of field of VIth lumbar nerve.

At 11.15 the IVth, Vth, VIIth, VIIIth, and IXth post-thoracic roots of the right side divided in the spinal canal. At 9.10 the field of cutaneous distribution of the VIth post-thoracic finally delimited.

"The field does not agree with the field delimited on the 20th in some points, but bears a strong general resemblance to it. It is limited by a line which may be followed from the skin over the Achilles tendon, about 5 centims. above the heel, and turns downward under the external malleolus to recurve upward along the peroneal group, soon bending backward, and lying on the outer head of the gastrocnemius. The line follows the middle of the popliteal space to reach the outer hamstring above that space, and, on the outer aspect of the thigh, turns down over the head of the fibula to reach the crest of the shin about 4 centims. below the patella, and slope over the inner aspect of the leg to the lower third of the leg, whence it returns again upwards between the inner malleolus and the tendo Achillis to reach the point it was traced from, about 5 centims. above the heel."

Ribs and lumbar vertebræ normal in number. Lumbar plexus markedly post-fixed.

VIth Post-thoracic.

Experiment.—*M. rhesus.* Female. 13.2.1891.

The IIIrd, IVth, Vth, VIIth, and VIIIth post-thoracic roots of the right side severed at 11.20. At 2 o'clock the field of cutaneous distribution of the VIth lumbar to touch was satisfactorily marked out. At 2.10 the rootlets composing the posterior half of the root were divided, and at 3.50 the cutaneous field of the reduced root again delimited, and finished at 4.15.

"The isolated field of reply occupies the distal extremity of the limb, and agrees closely with the area found in previous experiments to be that of the VIth post-thoracic. It is bounded by a line that can be traced from close above the internal malleolus upwards along the inner face of the tibial shaft and the inner condyle to the inner hamstring, the top of the popliteal space, and finally the biceps mass about half way up it. From that position, on the outer aspect of the thigh, it returns abruptly down the thigh, crosses the shin about 2 centims. below the tubercle of the tibia, and, running obliquely over the subcutaneous face of the tibia, gains the position whence it was traced."

At 2.10 the posterior half of the posterior root was cut through. The cutaneous field of reflex response was soon after roughly examined, but no distinct change in it detected. At 3.50 it was carefully examined in every part. "I cannot detect that the field is sensibly diminished in size. The only difference that is certain is a diminution, but not abolition, of the reflex response from the top of the ham, and to a less extent along the prominence of the calf." It was found the posterior half of the posterior root had really been severed, as supposed.

VIth Post-thoracic.

Experiment.—*M. rhesus.* Female. 20.2.1891. Plate 46, fig. 13.

At 10.50 the IInd, IIIrd, IVth, Vth, VIIth, and VIIIth roots of the post-thoracic nerves of the right side divided. At 4.30 the final estimation of the field belonging to the VIth lumbar root. The rootlets composing the posterior half of the root then severed. The cutaneous field of the anterior half of the nerve-root then compared with the previously delimited field one hour after the 2nd section.

"The isolated field of reply occupies the distal extremity of the limb, and is bounded by a line that is traceable as follows:—Commencing from a point about half way up the outer aspect of the thigh, and midway between its anterior and posterior borders, it runs down the thigh almost directly to reach the front of the head of the fibula. Continuing this oblique course downwards and inwards, it surmounts the crest of the tibia about the junction of the upper and middle thirds of that bone, and slants over the shin to a point about 3 centims. above the lower articular end of the bone. The line then abruptly ascends the inner aspect of the leg, passes along the back of the gracilis not far above the knee, sweeps obliquely upward and backward over the upper apex of the popliteal space, and finally over the edge of the outer hamstring to the point whence it was at first followed."

At 4.40 the lower half of the posterior root was severed. "At 5.45 the field was finally delimited in its present condition. No change was detected in the extent of the field in any direction except the following:—It was found that the boundary where it lies above the popliteal space, and especially on the outer hamstring, had retreated downward toward the knee. The amount of retreat is at most somewhat more than 1 centim. The reply to touch from the whole of the foot seems even more brisk than before, when the whole root was intact, but the skin on the summit of the calf seems to reply less briskly than before. Elsewhere no detectable difference appears at all.

Number of ribs and lumbar vertebræ normal.

VIth Post-thoracic.

Experiment.—*M. rhesus.* Female. 16.3.1891.

At 11.20 the IIIrd, IVth, Vth, VIIth, VIIIth and IXth post-thoracic spinal nerves (posterior roots only) of the right side divided. The isolated field of the VIth delimited finally at 4.45.

"The field of reply is evidently that of the VIth lumbar, and it corresponds so closely with the field found on the 13th and 20th of last month, there is no need for again describing it. There is distinct response from the whole of the outer edge of the foot. Perhaps the boundary above the inner malleolus is a little lower this time than usual."

Ribs and lumbar vertebræ normal in number.

VIIth Post-thoracic.

Experiment.—*M. rhesus.* Male; young. 27.10.1890.

Dimensions taken, *vide post.*

At 9.40 the XIth and XIIth thoracic, the Ist, IIIth, IVth, Vth, and VIth post-thoracic roots of the right side severed.

At 4.40 the edge formed by the combined field of VIIth and VIIIth and IXth post-thoracic roots finally determined.

"The limit of the posterior field of reply is a line which starts from a point in the mid-dorsal line about 4 centims. below the level of the anterior superior iliac spine. From that point it passes outwards and downwards, so that it lies more than 1 centim. in front and above the prominence of the great trochanter. It then turns downwards and backwards, crossing the shaft of the femur at about the junction of its highest and second quarters to descend well behind the outer condyle and in the semiflexed position of the knee about ·5 centim. behind the head of the fibula, crossing over the outer head of the gastrocnemius, and striking the suro-peroneal crease about half-way down the leg. It then runs close along the fibula and over the external malleolus along the middle of the dorsum pedis, where it becomes less sharp and distinct. In the sole it is found on the lateral aspect of the 1st digit at the side of the proximal phalanx, and following the edge of the interdigital web of the first space, it crosses boldly along the top of the eminence of the muscles of the hallux, and back to the posterior part of the inner malleolus. It thus divides the plantar surface into a somewhat scanty medial third, and a liberal lateral two-thirds, leaving the unhairy sole over the side of the calcaneum at a point about the junction of the most posterior with the next quarter of the inner edge of the foot. Ascending the leg it lies in the lower half of the leg, close behind the subcutaneous surface of the tibia, but it is curved in harmony with the contour of the inner head of the gastrocnemius muscle. It meets the thigh along the edge of the fold caused by the prominent posterior edge of the sartorius. Keeping to the posterior border of the inner aspect of the thigh it ascends to the pubic notch, reaching it on its ventral face."

The relative shares of the VIIth, VIIIth, and IXth roots in this line will be discussed later on.

Ribs and lumbar vertebræ are normal in number.

VIIth Post-thoracic.

Experiment.—*M. rhesus.* Female. 31.12.1890. Plate 46, fig. 14.

At 9.30 the posterior roots of the IIIrd, IV, Vth, VIth, VIIIth, and IXth post-thoracic roots of the right side divided.

At 1.40 the cutaneous field of the VIIth post-thoracic root delimited completely.

"The isolated field of reply is marked out by a line which has been traced from the plantar surface of the web between the 1st and 2nd digits, and runs along the middle of the ridge over the plantar muscles of the hallux to the groove on the inner side of the heel, tends up behind the inner malleolus along the inner edge of the flexor aspect of the leg, and behind the inner condyle, following the inner border of the thigh almost to the top of the thigh. It then turns backwards and upwards forming a short horn, and, keeping well lateral to the ischial callosity, runs upwards, and then bends inwards as if to reach the mid-dorsal line. It falls short of that line by suddenly recurving once more when it has approached about as far as a vertical let fall upon the ischial callosity. The second turn upon itself forms a long horn, the outer edge of which lies about midway between the anterior and posterior edges of the outer aspect of the thigh. The line then descends the thigh, inclining more and more to the posterior aspect of it. It then skirts along the outer edge of the calf, and slopes somewhat forward so as to run over the dorsum and reach the root of the second digit, and the point whence it was traced."

Ribs and vertebræ normal in number.

VIIth Post-thoracic.

Experiment.—*M. rhesus*. Female. 22.9.1890.

At 10.45 the IVth, Vth, VIth, VIIIth, and IXth post-thoracic roots (posterior divisions) divided on the right side.

At 2.10 the delimitation of the cutaneous field of the VIIth post-thoracic root completed.

Delimitation of the area of the VIIth post-thoracic nerve-root.

"The isolated field of reply is a long strip reaching from the hip to the end of the 3rd digit. Its boundary is traced as a line which may be followed from a point on the front of the ankle close outside the tendon of the tibialis anticus muscle, along the 2nd intermetatarsal space to the web between the 2nd and 3rd digits, and then along the dorsum of the 2nd digit and to the plantar aspect of that digit, and outward along the web between the 2nd digit and the hallux, and over the prominence of the plantar muscles of the hallux and the medial edge of the sole to the groove between the internal malleolus and the heel. Thence it runs upward along the inner edge of the gastrocnemius and along the inner border of the thigh to the lower end of the genital fold. At that point it slopes backward and still inward, and attains to a little more than 1 centim. from the symphysis. It then takes a backward direction and climbs over the buttock somewhat more than 1 centim. lateral to the lateral edge of the ischial callosity. At a level about 2 centims. above the top of the callosity it turns inward toward the mid-dorsal line over the root of the tail, and circumscribes a blunt-ended, somewhat hook-shaped peak lying almost over the hip-joint. From the highest part of this peak, which is 8 centims. below the anterior superior spine of the ilium and somewhat nearer the mid-dorsal line than is that spine, the line sweeps down the limb on the external aspect of the thigh, and continually approaching nearer the posterior border of the thigh in its descent. From lying a little in the anterior half of that aspect above, it crosses into the posterior half of that aspect below, so that at the level of the knee it lies on the outer aspect of the outer hamstring. In its further descent it sweeps forward, following the contour of the outer head of the gastrocnemius, and then in front of the peroneal group to a point on the anterior aspect of the ankle about midway between the two malleoli."

Ribs and lumbar vertebræ normal in number.

VIIth Post-thoracic.

Experiment.—*M. rhesus*. Male. 27.10.1890.

Measured :—

Top of symphysis to xiphoid	17	centims.
Tip of 12th rib to anterior superior spine	5·5	,,

The posterior divisions of the XIth, XIIth thoracic, the Ist, IIIrd, IVth, Vth, and VIth post-thoracic spinal nerves divided in the vertebral canal at 9.40.

At 6.10 the limits of the lower field of reply, mainly VIIth lumbar, determined.

"The lower field of response agrees closely with that found for the isolated VIIth lumbar root, on 22nd of last month. It is therefore mainly composed of VIIth, but VIIIth and IXth also come into it."

"Not so much of dorsum pedis as before."

Ribs and lumbar vertebræ normal in number.

*VIIIth Post-thoracic.**

Experiment.—*M. rhesus.* Female. 20.9.90.

At 9.10 A.M. the posterior roots of the Vth, VIth, VIIth, IXth, and Xth post-thoracic spinal nerves of the right side divided in the spinal canal.

At 11.15 the root of IVth lumbar of the right side divided also.

At 6.10 the determination of the field of the VIIIth post-thoracic completed.

"The isolated field of reply is contained by a line which can be traced as follows:—Starting from a point on the outside of the hip, about midway between the buttock and the inguinal fold, the line runs down the outer aspect of the thigh tending to pass to the posterior border of it. When on a level with the flexure of the ham it slopes inward more rapidly, and then descends on the calf to enclose a narrow tongue on the prominence of the calf and return over the inner hamstring, upwards, gradually encroaching on the inner border of the thigh. It ascends to the fold of the buttock and passes at an angle to its previous direction upward and backward on the medial side of the ischial callosity, and a short distance lateral to the root of the tail, to strike the point over the tip from which its course was traced."

"It was not until the IVth root had been severed that this area was isolated from the general upper field of reply, which latter field swept downward over the front of the thigh. After that last section the lower limit retired sufficiently to uncover the field of response that was then completely isolated, *i.e.*, that of VIIIth post-thoracic."

Ribs and lumbar vertebræ normal in number.

*VIIIth Post-thoracic.**

Experiment.—*M. rhesus.* Female; rather large. 24.9.1890.

At 12.45 the posterior divisions of the IVth, Vth, VIth, VIIth, IXth, and Xth post-thoracic spinal nerves divided on the right side in the vertebral canal.

At 6.30 the delimitation of the field of cutaneous distribution of the VIIIth post-thoracic root was finally complete.

"The isolated field of reply is a roughly quadrilateral patch. It is contained by a boundary which is traceable as follows.—Starting from a point on the extero-posterior aspect of the thigh on a level with the root of the tail, about 7 centims. below the level of the anterior superior spine of the ilium, and 4 centims. above the upper edge of the ischial callosity, and in a vertical falling ·6 centim. outside the lateral edge of the callosity, the line runs along the middle of the extero-posterior aspect of the thigh to a point somewhat behind the middle of the external surface of the knee, so as to be a little nearer to the free edge of the fold over the outer hamstrings than to the external border of the patella. The line then turns backward and downward, encloses a tongue-shaped extension on the upper part of the belly of the gastrocnemius, and re-ascends to the fold of the inner hamstrings and follows that fold to reach the surface of the adductor group and then the inner aspect of the thigh, rising in a little triangular extension on the front of the genital fold, and then attaining the mid-ventral line in the angle of the symphysis pubis. It laps across the median line but slightly as judged from the other side. It is found finally springing from the side of the vulval orifice about half-way between the anterior and posterior ends of that orifice and running outwards in an almost straight line, touching the posterior angle of the callosity, and reaching the point whence it was traced. This edge of the field is about parallel with the long axis of the callosity."

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* For this field *cf.* also Experiment given with figs. 3, 4, on pp. 688, 689

The ribs and vertebræ normal in number.

IXth Post-thoracic.

Experiment.—*M. rhesus.* Female; young. 10.10.1890.

Measurements:—

Anterior superior spine of ilium to tip of last rib . . .	5·5	centims.
Umbilicus to pubic crest	7·5	,,

The last thoracic and first two lumbar, and the IVth, Vth, VIth, VIIth, and VIIIth post-thoracic roots of the right side divided intraspinally at 11 o'clock.

At 4.30 the anterior border of the IXth post-thoracic root finally determined.

"The anterior limit of the gluteal field of reply is bounded by a line that can be traced from the mid-dorsal line, about on a level with the upper edge of the thigh when the hip joint is flexed. The line slants outward and downward, making at first an angle of about 18° with the transverse plane of the trunk. When about in the same vertical with the lateral end of the ischial callosity, it turns steeply downwards as far as a point on a level with the root of the tail, and about as far above the ischial callosity as the length of the long diameter of the callosity. The line then slopes inwards and downwards, and running lateral to the outer angle of the callosity follows the lower edge of the callosity, and at about 1 centim. from the middle line of the perineum runs forward to the under and anterior aspect of the symphysis.

"The two areas, right and left, if joined would make a quadrilateral patch, with a superior angle and an inferior angle in the middle line of the body; the lateral angles at some distance either side the root of the tail."

Ribs and lumbar vertebræ normal in number.

IXth Post-thoracic.

Experiment.—*M. rhesus.* Male. 19.10.1890. Fig. 5, next page.

Measurements not taken.

The posterior roots of the IIIrd, IVth, Vth, VIIth, and VIIIth post-thoracic spinal nerves of the right side divided in the vertebral canal at 10.10 A.M. At 6.30 the anterior edge of the IXth post-thoracic segmental field delimited.

"The anterior edge of the hinder field of reply is traced from the side of the genital flap to the outer side of the ischial callosity, and thence upwards and outwards along the outer edge of the callosity to sweep round the buttock as if it were the arc of a circle whose centre lay at the root of the tail, and finally attain the mid-dorsum about 2 centims. below the point at which the lower edge of the upper field of reply (the IInd lumbar root) attains it." (Fig. 5.)

IXth Post-thoracic.

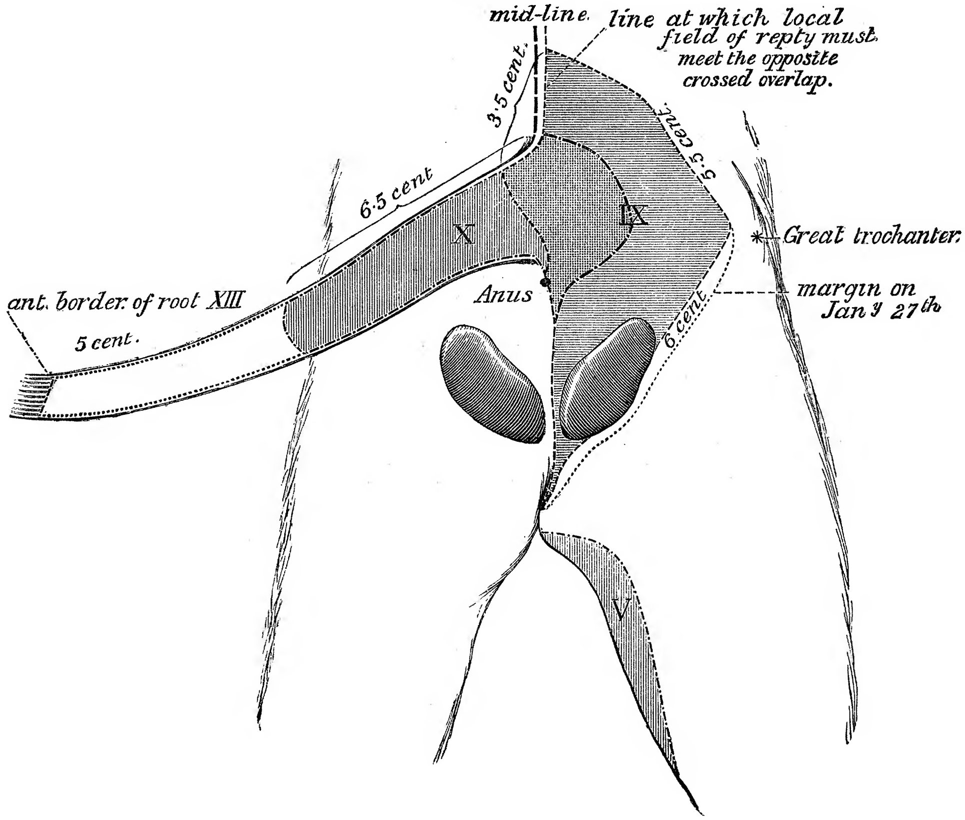
Experiment.—*M. rhesus.* Male. 27.1.1891. Figs. 5 and 6, pp. 722, 723.

The posterior divisions (roots) of the IIIrd, IVth, Vth, VIIth, and VIIIth post-thoracic spinal nerves divided in the vertebral canal at 12.25 P.M. The anterior border of the IXth post-thoracic field delimited at 6.30.

"The upper edge of the lower field of reply starts from the mid-dorsal line about 5 centims. below the level of the anterior superior spine of the ilium; the lower edge of the upper field of reply starts from the mid-dorsal line about on a level with the anterior superior spine, and the level at which the upper edge of the lower field lies at the mid-dorsum is about midway between the anterior superior spine and the ischial tuberosity. From that point the margin runs outwards, at first sloping downwards, then sloping more abruptly, and then turning inwards and downwards, so as to sweep about ·5 centim. outside the lower and lateral edge of the callosity and then runs forward under the inner edge of thigh up on to the front of the trunk along the lateral edge of the scrotum nearly as high as the root of the penis; at the root of the penis it meets the field of the upper roots."

At 7.30 the Ist lumbar root was severed on right side.

Fig. 5.



Sketch (made at the time).

" The lower field of reply on scrotum extends to same points as before, and it is now clear that replies from the side of the penis and from the glans penis which were taken to be part of field of the upper roots belong to the lower roots. It is not clear that the little area of reply which extends along the side of the penis and one-half the glans composes a field quite continuous with the scrotal field, because the replies are not obtained from absolutely the root of the organ; the penile field and the scrotal field are nearly continuous, but not quite, in this individual."

The penile and scrotal fields disappeared on section of the IXth post-thoracic root.

IXth Post-thoracic.

Experiment.—*M. rhesus.* Female; older. 12.11.1890. Plate 45, fig. 11.

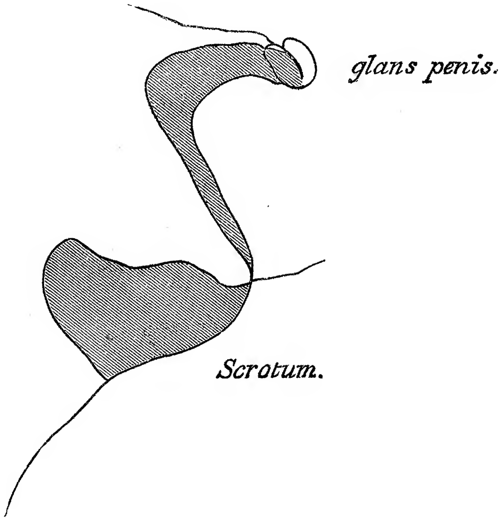
Dimensions, *vide* p. 702.

The Ist, IInd, IVth, Vth, VIth, VIIIth, Xth, and XIth post-thoracic roots of the right side severed at 11 o'clock.

At 5 o'clock the lower of the two isolated fields (that of the IXth post-thoracic) delimited for the last time.

" The lower of the two isolated fields of reply is of roughly rhomboidal shape. Its anterior edge starts from the mid-dorsal line at a point on a level about with the mid-point between the top of the iliac crest and the summit of the great trochanter, a point which is in this specimen about 2·5 centims. above the top of the great trochanter. The boundary slopes outward and backward, inclining with a slight convexity forward, to a point less than 3 millims. on the medial side of the posterior edge of the great trochanter, and on a level ·6 centim. behind the upper border of the great trochanter. A line drawn across from this point on the right side to a similar on the left passes above the anus and just under the root of the tail. From the point so described it slopes backward and inward to reach the mid-ventral line about ·4 centim. in front of the anterior end of the vaginal aperture, reaching this point by passing along the lower border of the ischial callosity.

Fig. 6.



Sketch (at the time).

" The posterior edge of this isolated field of reply is an arc which starts from the mid-dorsal line 3·5 centims. behind the anterior edge of the field, reaches near to the mid-ventral line at the root of the tail and attains the mid-ventral line at the dorsal edge of the anus."

Ribs and lumbar vertebræ normal in number (fig. 7).

IXth Post-thoracic.

Experiment.—*M. rhesus.* Female. 30.7.1890. Fig. 7, next page.

At 9.5 A.M. two of the post-thoracic roots divided in the vertebral canal, one on right side, one on left, the left-hand one is one segment lower than the right-side one. *Post-mortem* dissection showed these roots to be the VIIIth of right side, the IXth of the left side.

On following morning, at 12.30, examination of the skin by touching and pinching, revealed same condition as on the previous afternoon.

" No complete absence of sensation can be detected. But there is a distinct blunting of sensibility over a small quadrilateral area to the left of the root of the tail, and over a larger triangular area with its base at the right ischial callosity, and a tapering apex pointed down the back of the thigh."

Number of ribs and of lumbar vertebræ normal.

IXth Post-thoracic.

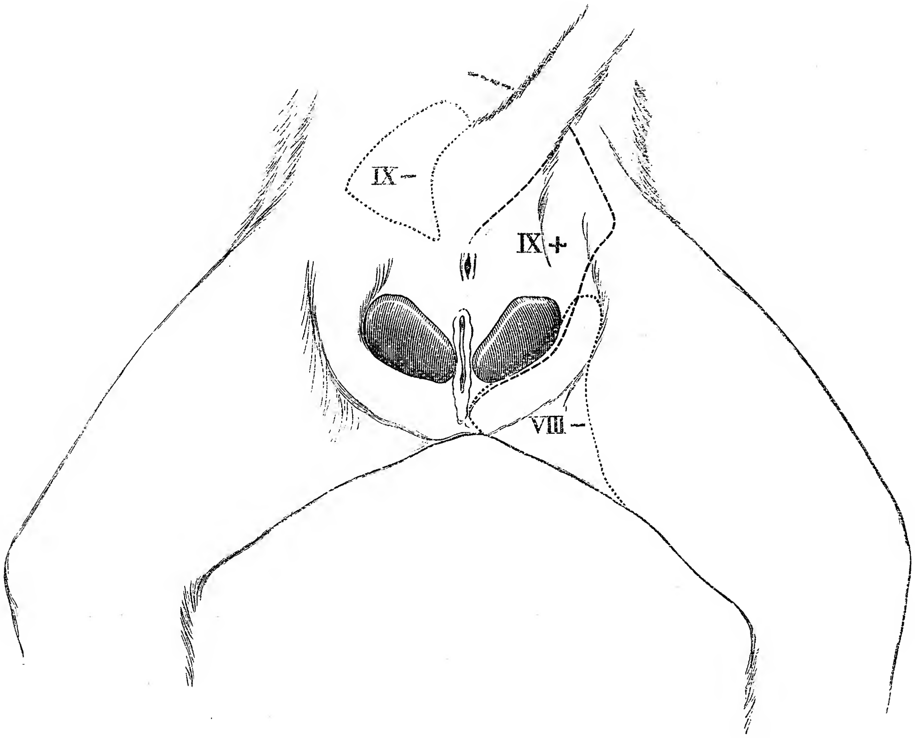
Experiment.—*M. rhesus.* Female. 4.4.1891.

At 8.50 the posterior roots of the XIIth thoracic, and Ist, IInd, IIIrd, IVth, Vth, VIth, VIIth, VIIIth, Xth, XIth post-thoracic spinal nerves divided.

At 1.50 the area of the Xth post-thoracic completely delimited.

"The field of reply is undoubtedly that of the Xth post-thoracic, for it agrees accurately with previous delimitations of that field. It passes from the dorsal crossed overlap above the root of the tail, and has a straight edge for some 7 centims. Then it turns backward at little greater than a right angle, and reaches the skin to the lateral side of the ischial callosity. It runs outside and below that callosity, and runs over the edge of the genital fold towards the front of the pubes, and then reaches the ventral crossed overlap."

Fig. 7.



The field of response (+) of root IX is sketched from the individual of 12.11.1890.

IX−. Patch where sensibility is obviously lowered after section of root IX.
VIII−. Similar patch after section of root VIII.
IX +. The field of response belonging to root IX.

"Behind, the edge of the field runs from the dorsal crossed overlap round the tail, close posterior to the root of it, and reaches the ventral crossed overlap just above the anus. At the mid-ventral line it includes the whole side of the labium vulvæ."

Ribs and lumbar vertebræ found normal in number.

Xth Post-thoracic.

Experiment. *M. rhesus.* Female; young. 19.5.1891.

At 10.15 the IVth, Vth, VIth, VIIth, VIIIth, IXth, XIth, and XIIth post-thoracic roots severed on the right side.

At 4.30 the area of cutaneous distribution of the Xth post-thoracic segment delimited finally.

"The limit of the isolated field of reply starts from the mid-dorsal line, close above the root of the tail, at a level a little above halfway between the posterior inferior spine of the ilium and the upper border of the callosity (*i.e.*, tuber ischii), sweeps downwards and outwards, with its concavity toward the root of the tail, to a point a little farther lateral than the middle of a line from the anus to the top of the great trochanter. Bending inward from that point, almost at a right angle, it follows fairly closely the line above mentioned toward the anus, but presently leaves it to meet the *labium vulvæ* about ·4 centim. from the posterior commissure."

"The posterior edge of the isolated field is a semicircle passing from the mid-dorsal line to the mid-ventral line on the tail, close behind the junction of the most anterior with the 2nd quarter of the length of the tail."

Xth Post-thoracic.

Experiment.—*M. rhesus.* Female; young. 31.10.1890.

Dimensions not taken.

The IInd, IIIrd, IVth, VIth, VIIth, VIIIth, and IXth post-thoracic roots of the right side severed at 8.50 A.M.

The XIth and XIIth roots severed at 5 o'clock.

The anterior border of the cutaneous field of the Xth post-thoracic finally defined at 4.30, about.

"The upper edge of the lower field of reply is limited by a line passing from the mid-dorsal line, just above the root of the tail, at a level about midway between the posterior inferior iliac spine and the upper border of the callosity; and from that point sweeps down and outward, then downward, then downward and inward, and attains the mid-ventral line at the posterior angle of the vaginal orifice. It is notable that although only one root was divided, there is about 3 centims. down the tail a semicircular zone of depressed reflex reply, so that the overlap of the skin fields seems less on tail than trunk and extremity."

At 6.30 the posterior border delimited.

"A semi-circular zone of greatly lowered response lies at the junction of the 1st and 2nd quarters of the tail. It is not strictly semicircular, but about one-third of a circle in extent, and about ·8 centim. wide. It is on the right side of the tail."

Ribs and lumbar vertebræ normal in number.

Xth Post-thoracic.

Experiment.—*M. rhesus.* Male; young; testes undescended. 29.10.90. Fig. 5, p. 722.

Measurements:—From xiphoid to the top of the symphysis pubis is 17 centims.

At 11.10 the VIth, VIIth, VIIIth, IXth, XIth, and XIIth post-thoracic roots of the right side severed.

At 4.50 the field of cutaneous distribution of the Xth post-thoracic root delimited for the last time.

The anterior edge of the isolated field of reply starts from the mid-dorsal line, just above the root of the tail; sweeping downwards and outwards it curves round the root of the tail, so as to turn inwards towards the anal orifice about 1·5 centim. above the callosity. When on a level with the anal orifice it lies about ·5 centim. above the level of the highest point of the callosity, and above ·8 centim. from the anal aperture; then it descends and runs forward, reaching the raphe about 1 centim. in front of the anus."

"The posterior edge of the isolated field of reply starts from the mid-dorsal line, upon the tail, 6 centims. from the root of the tail; it sweeps round from the dorsum to the venter, and there is a considerable crossed overlap, as judged from the distance which the anæsthetic skin field falls short of the mid-dorsal line and mid-ventral line, at least 4 millims."

Autopsy verified the normal number of thoracic and lumbar roots.

Xth Post-thoracic.

Experiment.—*M. rhesus.* Female; young. 19.11.1890.

Measurements as on p. 711.

At 12.15 the Ist, IInd, IIIrd, and the Vth, VIth, VIIth, VIIIth, and IXth post-thoracic roots of the right side severed.

At 5.20 the anterior border of the cutaneous field of the Xth post-thoracic root determined finally.

"The anterior edge of the posterior field of reply starts from the mid-dorsal line, 1 centim. behind the posterior border of the isolated field of reply (IVth lumbar) and runs outward for 38 centims., approaching as it does so to ·4 centim. of the posterior border of the isolated field of reply (IVth lumbar). It then turns abruptly backwards towards the callosity."

Ribs and lumbar vertebræ normal in number.

Xth Post-thoracic.

Experiment.—*M. rhesus.* Male. 3.11.1890.

Measurements :—

Anterior superior spine of ilium to the ligamentum patellæ .	18 centims.
Symphysis pubis to umbilicus	8·5 „

Anterior border of the Xth post-thoracic root-field. The IIIrd, IVth, VIth, VIIth, VIIIth, and IXth post-thoracic, and later the IInd post-thoracic root severed in the spinal canal. The anterior border of the Xth post-thoracic determined finally at 5.20, about.

"The outer edge of the gluteal field of response can be traced from the mid-ventral line at the side of the penis, backward over the scrotum, and internal to the ischial callosity between it and the anus, and then encircles the root of the tail to meet a point on the mid-dorsum immediately above the root of the tail."

Xth Post-thoracic.

Experiment.—*M. rhesus.* Female. 25.10.1890.

The posterior divisions of the IVth, Vth, VIIth, VIIIth, and IXth post-thoracic spinal nerve of the right side divided in the vertebral canal at 11.15.

At 8.15 the field of cutaneous distribution of the Xth post-thoracic root was delimited for the last time.

"The anterior edge of the lower field of reply starts from the dorsal crossed overlap about 1 centim. behind the lower edge of the upper field of reply. It passes outwards almost horizontally, and nearly meets the upper field, and then curves backward and reaches the outer angle of the ischial callosity."

The upper field of reply was here the IIIrd lumbar, and for the Xth post-thoracic to approach so close to the IIIrd is quite unusual. The Xth post-thoracic in this individual extended more anteriorly (*i.e.*, further upward and toward great trochanter) and less far posteriorly on tail than usual. It included the anus as usual, and part of Vth and IVth also. The number of ribs and of lumbar vertebræ was found to be normal. The lumbo-sacral plexus was found on dissection to be markedly post-fixed.

XIth Post-thoracic.

Experiment.—*M. rhesus.* Male; young. 24.11.1890. Plate 44, fig. 7.

Measurements:—

Pubes to infrasternal notch	16 centims.
Vertical distance from nipple to anterior superior spine of ilium .	14 ,,

The two lowest thoracic and the IInd, IIIrd, IVth, VIth, VIIth, VIIIth, IXth, and Xth post-thoracic roots divided intraspinally at 9.10 A.M.

At 5 the anterior border of the XIth post-thoracic root determined.

"The anterior edge of the tail field of reply is a line that runs round the side of the tail, from mid-dorsal line to mid-ventral line, at about the junction of the most proximal with the 2nd quarter of the tail. In front of it there is evidence of a good half-centimetre crossed overlap both ventrally and dorsally."

XIth Post-thoracic.

Experiment.—*M. rhesus.* Female. 12.11.1890. Plate 45, fig. 11.

Detailed above, gave practically the same result as regards anterior edge of the XIth post-thoracic as did the experiment above.

XIth Post-thoracic.

Experiment.—*M. rhesus.* 24.9.1890.

In which the IVth, Vth, VIth, VIIth, IXth and Xth post-thoracic roots were divided, gave practically the same result as the above two in November.

XIIIth Post-thoracic.

Experiment.—*M. rhesus.* Male. 29.10.90.

Measurements, *vide* p. 712.

At 11.10 the VIth, VIIth, VIIIth, IXth, XIth, and XIIth roots of the right side severed.

At 6 o'clock the anterior edge of the cutaneous field of the XIIIth post-thoracic ascertained finally.

"The anterior edge of the field of reply, which includes the tip of the tail, runs round the tail from mid-dorsal line to mid-ventral line 14·5 centims. from the root of the tail, 7 centims. behind the posterior edge of the isolated skin field." (Xth post-thoracic root.)

Vth Post-thoracic.

Experiment.—*Cat.* Female; young. 19.1.1891.

Delimitation of the field of the Vth lumbar root of the right side.

10.30. The Ist, IInd, IIIrd, IVth, VIth, VIIth, VIIIth, and IXth post-thoracic nerves (posterior roots only) divided on the right side.

At 1.30 the cutaneous field finally delimited.

"A triangular field with the base upward, above the knee, and occupying chiefly the outer side of the thigh, the inner aspect of the leg, the inner side of the foot more than half-way to the toes. A deep notch in the upper border (base) of the triangular field extends towards the inner side of the knee. The minimal reply obtained in the testing was always flexion of the toes."

Later, by excitation of the anterior roots it was found that the arrangement of the motor side of the plexus was *prefixed* in character. Thus excitation of the IXth post-thoracic root gave no movement in the limb muscles at all, but closure and detrusion of anus and movement of tail. And this prefixture on efferent side of the plexus was accompanied by prefixture of the afferent fibres because the knee jerk was well retained after section of the posterior root of the VIth lumbar nerve, whereas section of that afferent root usually abolishes it. By dissection, the plexus was also found to be decidedly prefixed. The ribs were thirteen and the lumbar vertebræ seven, *i.e.*, both normal in number.

INDEX to Series of Experiments on the Sensory Spinal Skin-fields of *Macacus rhesus*. Experimental Series II.

Segmental number of the skin-field examined.	Page.	Date of experiment.	Reference number of plate or figure.
4th Post-thoracic . 8th 11th	688	20.10.1890.	
4th Thoracic . . **1st** 5th	691	22.6.1891.	
5th Thoracic . . . **1st** 6th	692	25.5.1891.	
4th Thoracic . . . **2nd** 7th	692	5.8.1891.	Plate 42, fig. 1.
2nd Cervical . . . 5th Thoracic . . . **2nd** 6th	693	18.6.1891.	
2nd Cervical . . . 6th 3rd	693	10.6.1891.	
7th Thoracic . . . **3rd** 8th	694	28.5.1891.	
3rd Thoracic . . . **3rd** 7th	694	26.8.1891.	Plate 42, fig. 2.
3rd Thoracic . . . 6th 9th	695	6.4.1891.	
3rd Thoracic . . . **4th** 7th	695	22.10.1891.	Plate 43, figs. 3 and 5.
3rd Cervical . . . 7th **4th**	696	2.4.1891.	
4th Thoracic . . . 7th 10th	697	17.12.1890.	
3rd Cervical . . . 8th **5th**	697	7.6.1891.	

INDEX to Experiments of Series II.—(continued).

Segmental number of the skin-field examined.	Page.	Date of experiment.	Reference number of plate or figure.
Thoracic . . . 1st < 4th / **5th**	697	22.6.1891.	
Thoracic . . . 6th < 5th / **6th**	698	25.5.1891.	
Thoracic . . . **6th** < 3rd / 9th	698	6.4.1891.	
Cervical . . . 5th / 2nd | Thoracic . . . 2nd \ **6th**	699	18.6.1891.	
Thoracic . . . 2nd < 4th / **7th**	699	5.8.1891.	
Thoracic . . . **7th** < 4th / 10th	699	17.12.1890.	Plate 43, figure 4.
Thoracic . . . 11th < **7th** / 8th	700	27.11.1890.	
Thoracic . . . 4th < 3rd / **7th**	700	22.10.1891.	
Thoracic . . . 3rd < 3rd / **7th**	701	26.8.1891.	Plate 42, figure 2.
Thoracic . . . 3rd < 7th / **8th**	701	28.5.1891.	
Thoracic . . . . . (**8th** / 11th	702	8.6.1891.	
Thoracic . . . 6th < 3rd / **9th**	702	6.4.1891.	
Thoracic . . . 12th < **9th** / 4th	702	17.11.1890.	
Post-thoracic . 1st / **10th** | Post-thoracic . 5th \ 11th	703	24.11.1890.	Plate 44, figure 7.

INDEX to Experiments of Series II.—(continued).

Segmental number of the skin-field examined.	Page.	Date of Experiment.	Reference number of plate or figure.
4th Thoracic . . . 7th **10th**	703	17.12.1890.	
10th Thoracic 2nd	703	15.10.1890.	
8th Thoracic **11th**	704	8.6.1891.	
11th Post-thoracic . 3rd 9th	704	10.10.1890.	
12th Post-thoracic . 3rd Post-thoracic . 9th 11th	704	12.11.1890.	
9th Thoracic . . . **12th** 4th	705	17.11.1890.	Plate 44, figure 8.
12th Post-thoracic . 3rd 10th	705	19.11.1890.	Plate 44, figure 6.
11th Post-thoracic . 3rd **12th** 9th	705	7.1.1891.	
11th Post-thoracic . 3rd **12th** 9th	706	12.11.1891.	Plate 45, figure 11.
1st Post-thoracic . 5th 10th	706	31.10.1891.	
10th Post-thoracic . **1st** Post-thoracic . 5th 11th	706	24.11.1890.	Plate 44, figure 7.
1st Post-thoracic . 6th 9th	707	20.2.1891.	
1st Post-thoracic . 5th 11th	707	22.12.1890.	

INDEX to Experiments of Series II.—(continued).

Segmental number of the skin-field examined.	Page.	Date of Experiment.	Reference number of plate or figure.
10th Post-thoracic . **2nd** 7th	707	27.10.1890.	
2nd Post-thoracic . 6th 9th	708	13.2.1891.	
1st Post-thoracic . 5th **2nd** 10th	708	3.11.1890.	
2nd Post-thoracic . 6th 9th	709	19.10.1890.	
3rd Post-thoracic . 10th 13th	709	19.5.1891.	
12th Post-thoracic . **3rd** Post-thoracic . 9th 11th	709	12.11.1890.	Plate 45, figure 11.
3rd Post-thoracic . 6th 10th	710	25.10.1890.	
11th Post-thoracic . **3rd** 9th	710	10.11.1890.	
9th Thoracic . . . 12th **4th**	711	17.11.1890.	Plate 44, figure 8.
9th Thoracic . . . 12th Post-thoracic . **4th** 10th	711	19.11.1890.	Plate 44, figure 6.
3rd Post-thoracic . 8th **4th** 11th	712	26.9.1890.	
5th Post-thoracic . 10th 13th	712	29.10.1890.	
10th Post-thoracic . 1st Post-thoracic . **5th** 11th	713	24.11.1890.	Plate 44, figure 7.

INDEX to Experiments of Series II.—(continued).

Segmental number of the skin-field examined.	Page.	Date of experiment.	Reference number of plate or figure.
1st Post-thoracic . **5th** 10th	713	31.10.1890.	Plate 46, figure 12.
1st Post-thoracic . **5th** 11th	714	22.12.1890.	
9th Post-thoracic . 1st Post-thoracic . **5th** 11th	715	29.12.1890.	
1st 2nd Post-thoracic . **5th** 10th	715	3.11.1890.	
12th Post-thoracic . **6th** 10th	715	27.1.1891.	Plate 45, figures 9 and 10.
2nd Post-thoracic . **6th** 9th	716	19.10.1890.	
3rd Post-thoracic . **6th** 10th	716	25.10.1890.	
2nd Post-thoracic . **6th** 9th	717	13.2.1891.	
1st Post-thoracic . **6th** 9th	717	20.2.1891.	Plate 46, figure 13.
2nd Post-thoracic . **6th** 10th	718	16.3.1891.	
10th Post-thoracic . 2nd **7th**	718	27.10.1890.	
2nd Post-thoracic . **7th** 10th	718	31.12.1890.	Plate 46, figure 14.
3rd Post-thoracic . **7th** 10th	719	22.9.1890.	
10th Post-thoracic . 2nd **7th**	719	27.10.1890.	

INDEX to Experiments of Series II.—(continued).

Segmental number of the skin-field examined.	Page.	Date of experiment.	Reference number of plate or figure.
Post-thoracic . **8th** < 3rd 4th 11th	720	20.9.1890.	
Post-thoracic . **8th** < 3rd 11th	720	24.9.1890.	
Post-thoracic . 3rd < 11th **9th**	721	10.10.1890.	
Post-thoracic . 6th < 2nd **9th**	721	19.10.1890.	Figure 5, p. 722.
Post-thoracic . 6th < 2nd **9th**	721	27.1.1891.	Figures 5 and 6, pp. 722, 723, and Plate 47.
Post-thoracic . 3rd < 12th **9th**	722	12.11.1890.	Plate 45, figure 11, and figure 7, p. 724.
Post-thoracic . . . (8th **9th**	723	30.7.1890.	Figure 7, p. 724.
Post-thoracic . **9th** < 11th 13th	724	4.4.1891.	
Post-thoracic . **10th** < 3rd 13th	725	19.5.1891.	
Post-thoracic . 5th / 1st Post-thoracic . **10th** \ 13th	725	31.10.1890.	Plate 46, figure 12.
Post-thoracic . **10th** < 5th 13th	725	29.10.1890.	Figure 5, p. 722, and Plate 46.
Post-thoracic . 4th < 12th **10th**	726	19.11.1890.	
Post-thoracic . 5th < 1st 2nd **10th**	726	3.11.1890.	
Post-thoracic . 6th < 3rd **10th**	726	25.10.1890.	

INDEX to Experiments of Series II.—(continued).

Segmental number of the skin-field examined.	Page.	Date of experiment.	Reference number of plate or figure.
╱10th Post-thoracic . 1st | Post-thoracic . 5th ╲**11th**	727	24.11.1890.	Plate 44, figure 7.
╱10th Post-thoracic . 1st | Post-thoracic . 5th ╲**11th**	727	25.11.1890.	Plate 45, figure 11.
╱1st Post-thoracic . 8th ╲**11th**	727	24.9.1890.	
╱5th Post-thoracic . 10th ╲**13th**	727	29.10.1890.	
╱3rd Post-thoracic . 8th ╲11th	688	4.5.1891.	Figures 3 and 4, pp. 688, 689.
Cat—			
╱12th Post-thoracic . **5th** ╲10th	727	19.1.1891.	

CONCLUSIONS.

When the facts of the above arrangement are compared with those found to exist in the Frog (*v. supra*, p. 652, &c.), it will be seen that considerable differences between the two schemes of distribution become apparent. It seems well to return to the conclusions arrived at for *Rana*, and examine the extent of their applicability to *Macacus*.

1. Although in a plexus each spinal nerve-root affords separate contributions to many several nerve-trunks in the plexus, the cutaneous distribution of the root is composed, not of patches which are disjoined, but of patches which are so joined that the distribution of the entire root forms one continuous field.

Looking over the areas determined for *Macacus* in the foregoing experiments, it is seen that, just as in the leg of the Frog, so with the nerve-roots of the trunk and lower limb of *M. rhesus*, each root possesses a single undivided field of cutaneous distribution, not a field composed of separated patches. This is a point to which attention was always paid in the experiments, because it was remembered that TÜRCK found evidence of such "divided" fields in the case of certain nerve-roots, viz., the IInd and IIIrd thoracic roots of the Dog; also because such an arrangement might exist with the more complexly branched plexus of *Macacus*, although absent from the simpler type of the Frog. In *Macacus* no evidence of this division of the skin-field of the root was found. There was once noticed, it is true, in an experiment upon the IInd thoracic root, a small area, about an inch long,* which *appeared* to be not perfectly continuous with the otherwise perfectly continuous field of reply referable to that root; but this outlying islet did not appear in other delimitations of the IInd thoracic field, and it was well within the limits of error which must be acknowledged for the experiments. My experimental fields probably understate, perhaps in certain directions considerably, the real area of skin-field of the root. The above apparent exception to the general statement is, therefore, mentioned, but is not believed to really modify the statement. Another instance of an outlying islet of æsthesia, apparently detached from the general field at the rest of the root, occurred in an experiment on the IXth post-thoracic. One-half of the scrotum is included in the field of the IXth post-thoracic, and also the corresponding half of the penis, but I could not demonstrate the conjunction of the scrotal and penile fields at the root of the penis.† I think this probably due to my experimental field being a minimal representation of the true root-field, and that probably the skin at the root of the penis is included in the root-field, and through it the penile and scrotal fields are conjoined.

Similarity of the root compositions of neighbouring nerve-twigs that are near their destination is a necessity of the above arrangement. Thus, the dorsal collateral digital nerve on the tibial side of a digit will resemble in composition the plantar collateral digital on the tibial side of the same digit, and this is exemplified in the table of analysis of peripheral nerves given above. This is comparable to the similarity of root composition exhibited by the several motor twigs entering a skeletal muscle in the limb. Thus, the tibialis anticus receives fibres from the anterior roots of at least two spinal nerves entering the plexus, and receives those fibres by several separate nerve-branches entering the muscle; in each of the nerve-branches will be found a proportion of fibres from each of the roots supplying the muscle, and in fairly similar proportions in all. But there are exceptions, thus the upper and lower nerves to the sartorius, the upper nerves containing the fibres from the IIIrd and IVth lumbar roots, the lower from the IVth and Vth lumbar roots. So also adductor magnus.

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* *Cf.* Photograph 1, Plate 42.

† *Vide* sketch, (fig. 6, p. 723).

On the dorsum of the foot a somewhat curious anatomical arrangement of the peripheral nerves to the skin of the toes is the interposition between the digitales communes from the musculo-cutaneous trunk of a similar trunk for the cleft between hallux and 2nd digit supplied from the anterior tibial nerve. I looked with some interest to see whether the root composition of the branch from the anterior tibial would fall into series with the arrangement of the root composition of the digitals from the musculo-cutaneous. In the latter, as traced from the tibial toward the fibular edge of the foot, *i.e.*, from the preaxial toward the postaxial border, the proportion of fibres from the Vth lumbar root rapidly diminishes to disappearance, a proportion of fibres from the VIIth lumbar root appears and gradually increases. In *Rhesus* (and also in Cat) experiments disclose (pp. 668 and 679) that the branch from the anterior tibial falls into perfect series with the rest as far as its root composition is concerned, and can be analysed by the experiments above. The case is comparable with that of the external saphenous nerve in *Macacus* and the plantar muscles.* Despite the existence of some latitude of individual variation (*vide infra*), the connection between the position of the central end of a sensory nerve fibre and that of the peripheral end is, in one and the same individual, definite and fixed enough. In other words, the mutual relationship between the position of points composing a region of the body is specific, the absolute position of the whole region is largely individual.

2. The field of skin belonging to each sensory spinal nerve-root overlaps the skin fields of the neighbouring spinal nerve-roots to a remarkable extent. The disposition is such that the field laps to a certain extent over the field of the root or roots immediately in front of it, and to a certain extent over the field of the sensory roots immediately behind it. These two overlaps may be termed respectively the anterior overlap and the posterior overlap of the sensory root field. (See diagrams, Plate 52.)

The above conclusion is applicable without modification to the arrangement existing in *Macacus*. The overlap is very great, so great indeed that each point of skin is supplied by two spinal nerve-roots, and some, it would appear, by three. And this overlap is true for the nerves of the trunk as well as for those of the limb. Thus the nipple is a point of skin which lies in the field of the IVth thoracic root, often a little nearer the posterior than the anterior border of that field. Now the nipple is included also in the experimental field of the Vth thoracic root, the anterior border of which passes above it; and the nipple was found on two of three occasions on which the posterior border of the field of the IIIrd thoracic root was examined to lie demonstrably in the experimental field of that root, although on one occasion the border passed just above the nipple itself, including only the areola above the nipple. In the foot the mid-point of the border of the web between hallux and 2nd digit is included in the experimentally demonstrable field of the VIth lumbar root; it is also generally included in the experimentally demonstrable fields of the Vth lumbar and VIIth lumbar roots, but it lies at the very confines of those fields. The skin of the upper part of the ham is included in the fields of the VIIth and VIIIth post-thoracic roots.

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* SHERRINGTON, 'Journ. of Phys.,' 13, p. 739.

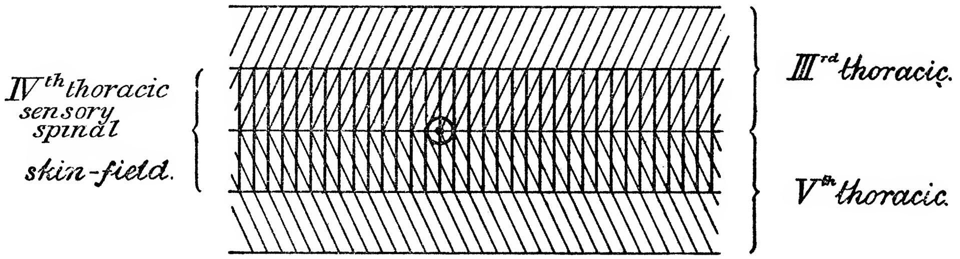

Diagram of the position of the nipple in the sensory skin-fields of the IVth, IIIrd and Vth thoracic spinal roots.

Acknowledging that the size of the experimental skin-fields is somewhat smaller than the size of the skin-fields in reality, I conclude that the anterior and posterior overlaps are extensive enough in the Monkey to provide that the skin, taken along any line parallel with the plane of segmentation of the body in the region in which the line is taken, is supplied by two adjacent posterior roots. It further seems certain that in certain places the skin is supplied by three adjacent posterior roots, more by the middle of the three roots, less by the foremost, and by the hindmost of the three roots individually taken. Possibly skin in which the interlap is thus triple instead of double exists along the centre of the cutaneous segments of the body. In the sole (Cat) the anterior border of the skin-field of the lowest of three* roots overlaps the posterior border of the skin-field of the highest root of the three. The amount of supply given to its skin-field by a given root appears to vary in different parts of the field, and it is usual for the border of the field to be less richly supplied than the rest of the field. Thus the nipple lies about midway in the field of the 4th cutaneous segment of the thorax, and it is in each normal individual probably supplied by the Vth thoracic and the IIIrd thoracic afferent roots, as well as by the IVth. It would therefore lie in one of the narrow zones of triple interlap above mentioned. I have met with an instance in which it was included in the anterior edge of the 6th thoracic skin-field.* In the trunk the degree of overlap of the skin-fields often seems to be less near the mid-dorsum and mid-ventral lines than on the lateral aspect at some distance from those lines. It must be remembered that the nipple lies in this lateral region, and so also, as I shall point out later, does the foot with its digits, again a region of remarkable overlapping.

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* These are VIth, VIIth, and VIIIth post-thoracic. See also Tables, pp. 668, 679, 685.

Beside the anterior and posterior overlaps, the cutaneous field of each posterior root oversteps the median line of the body both ventrally and dorsally. This crosslap of right and left-hand nerves is not so extensive as the overlap fore and aft. It is comparable with the lapping across the dorsal median line of the distribution of the pilomotor nerves in the Monkey and Cat as described by LANGLEY and myself.† It seems to vary in *Macacus* in different regions. It seems more marked along the mid-ventral line than along the mid-dorsal line, and I have seen it remarkably extensive on the penis, and close below the xiphoid. I do not think I have ever seen it amount to more than a full centimetre in *Macacus*, but all the specimens have been small and the crosslap might be larger in larger individuals. The amount of supply by the root to the cross-lapping border of the field appears relatively small compared to elsewhere in the field, in fact it resembles in this way the extreme border of the forelapping and afterlapping portions of the skin-field.

Where seen at its simplest, viz., in the thoracic region, the shape‡ of the cutaneous field of the posterior root is that of a horizontal band with fairly parallel edges wrapping half round the body between the mid-dorsal and mid-ventral lines. In the lower half of the thorax each zone thus formed slopes somewhat, so that the ventral end of it appears to lie further caudal than the dorsal end of it. Each zone is narrowest at its dorsal end, and widest somewhere not far from its ventral end. The width of the individual zones gives us some idea as to how the external configuration of the body has been brought about. Where the body approaches a regular figure, a cylinder, a double cone, &c., the root-field is zonal, possessing long anterior and posterior sides fairly parallel each with the other, and short dorsal and ventral sides set approximately at right angles to the anterior and posterior. If the whole animal were a cylindrical, simple figure, this configuration of the root-field would presumably hold good for all its segments, as it presumably approximately does in such a form as *Amphioxus*. But where the animal form is less regular the simple zonal shape set fairly at right angles to the body axis is departed from in many ways. The antero-posterior width of the skin strip may be increased at one part or another by an extension forwards of the anterior border, or an extension backward of the posterior border. The ventral border may be thrown backwards and the skin strip thus come to be obliquely set. The anterior and posterior borders may become curved, and one of them be more curved than the other, or both of them be fairly similarly curved, so that their parallelism is still roughly maintained.

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* The difficulty is to estimate coincidently the overlapping and the individual variation.

† 'Journal of Physiology,' 12, p. 278.

‡ In illustration of the text from here to p. 749, see especially the areas as painted out on casts taken from a small *M. rhesus*.—Plates 47–51 inclusive. Also the diagrams on Plate 52.

If these departures from the simple zonal type of root-field afford a hint as to the modifications which body-segments have individually undergone in the development of the present configuration of the animal, it would seem that in the abdominal region of *Macacus rhesus* each root-field has become expanded at its ventral end. Also one can notice in *Macacus rhesus* that in the region of the abdomen and the loin the zonal root-fields are individually wider than in the thoracic region. The mid-ventral line, from the top of the sternum to the pubes, is seen to correspond segmentally with the mid-dorsal line along the region of the thoracic vertebræ. The length of that portion of the mid-ventral line was 31 centims. in an individual in which the corresponding portion of the mid-dorsal line measured only 21 centims. It is seen that that is explicable by the ventral ends of the root fields being wider than the dorsal ends of them, and that the difference is greatest for the lowest two thoracic and the highest lumbar segments.

In the animal body the greatest departure from a simple and regular figure is caused in the vertebrate forms by the excrescence of the limbs. How does the segmentation of the body behave in the region of the limbs ? In the Frog it has been shown above that the simple zonal character of the root-fields, although disturbed in the hind limb, is not actually departed from and is still easy to perceive. "The cutaneous field for each posterior root meets the middle line of the body both ventrally and dorsally." Each root-field sweeps down the limb and up again upon it, so that the free apex of the limb is by this test about equidistant from the mid-ventral and mid-dorsal lines; the digits are, in fact, so many points on the lateral line of the body, as they were shown to be at the earliest origin in the embryo. The most segmentally anterior portion of the skin of the hind-limb of the Frog is found to occupy the extensor aspect (front) of the thigh. Next come the extensor and peroneal aspects of the leg, then the dorsum pedis, the sole, the calf, and, finally, the most segmentally posterior is the flexor aspect (back) of the thigh. It is the comparatively small number of nerve-roots distributed to the hind limb of *Rana* that in its case makes the arrangement of such an obvious kind. The skin of the limb in *Rana* is supplied practically by four roots only.

Turning to *Macacus rhesus*, one finds that if the surface of the limb be considered to be bounded proximally by POUPART's ligament, and by a line passing from the anterior superior spine backwards over the ischial tuberosity to the genital fold, the skin of the limb has eight roots contributing to its supply.

A salient difference between the distribution of the skin-fields of these, and that of the root-fields in the hind limb of *Rana*, is that in the case of the former certain root fields do not conform to the conclusion above drawn from *Rana;* that is, they do not meet the middle line of the body either ventrally or dorsally. The skin-field of the posterior root of the IVth lumbar nerve sweeps from the median line of the back, not to the median line of the belly, but to the inner edge of the thigh and leg. The field of the Vth lumbar is everywhere widely distant from the median line of the back and the median line of the belly. The field of the VIth lumbar is entirely confined to the distal portion of the limb. The field of the VIIth lumbar, also, is wholly separate from the median line of the back and belly. The field of the first sacral I have failed to find extending to the median line of the back, although in the female it does seem to reach the ventral median line upon the pubes. In other words, tracing downward the body segments of *Macacus*, as indicated by the cutaneous distribution of the sensory spinal roots, one finds, on arriving at the IVth lumbar segment, that the succeeding segments, as regards the skin, become entirely limb segments, and slip outwards down the limb, and then return upward upon it again, regaining the median line of the body completely only when the IInd sacral nerve is reached. Further than this, they leave the mid-dorsal line of the body nearly a segment lower than they leave the mid-ventral line. In each of the median lines of the body, the segments leave and return to the line at the same definite point. The position of this point in the mid-dorsal line of the body is decidedly below the level of midway between the anterior superior spine of the ilium and the bottom of the tuber ischii; in the mid-ventral line of the body the point is on the front of the pubes, and in the female appears to be lower down on the pubes than in the male.

To ascertain in what way the shape of the simple zonal root-field, which one has considered typical, is modified in the configuration of the limb, it is essential to discover the positions of the four borders of the field—the anterior, posterior, ventral, and dorsal. The distortion may have unequally affected these four borders. In order to do this one begins best, perhaps, by observing the position and character of the borders of these root-fields, which only partially contribute to the surface of the limb, and in which the dorsal and ventral borders obviously follow the mid-dorsal and mid-ventral lines of the body. The highest root-field to contribute to the limb is that of the Ist lumbar. This is distorted from the simple zonal form only in its ventral half, and its distortion is mainly caused by the extension backwards of its posterior border, so that it becomes much wider at its ventral end. Its posterior border thrusts also a curious shallow flap across the fold of the groin into the thigh over about the middle of POUPART's ligament. The IInd lumbar root-field resembles in shape an exaggerated Ist lumbar field. The exaggeration of the flap down the extensor surface of the thigh is caused partly by the ventral end of the posterior border returning toward the pubes, and the flap may extend a full third of the way to the knee. In the IIIrd lumbar root-field the thigh flap assumes still greater proportions, and involves, at least, two-thirds of the whole posterior border. Its flap covers the greater part of the whole anterior aspect of the thigh, and resembles somewhat the flap that the surgeon used to cut in amputation above the knee. Just as in the case of the IInd lumbar field, so in the IIIrd lumbar the posterior border on median side of the flap retires again toward the mid-ventral line on the pubes. So far, then, the root-fields contribute to the surface of the limb by an extension from their posterior border in its lateral portion, lying somewhat more perhaps to the ventral than to the dorsal side of the mid-lateral line of the body.

The disposition of the contribution of the IVth lumbar skin-field to the limb is less simple to discover. The field sweeps from the median line of the back over the ilium, down the extensor face of the thigh, over the knee and inner face of highest part of the leg, to the inner border of the thigh, *i.e.*, the skin covering the gracilis, and to the inner line of attachment of the calf muscles. Its shape implies that the whole of the ventral portion of its posterior border has contributed to the limb in a flap still greater than that protruded from the posterior border of the preceding field. It is true that the border does, in the leg, curve slightly upwards again as if making for the pubes, but it falls far short of reaching it; it reaches only to the inner border of the thigh. Which of its periphery is therefore its ventral border? Before deciding, it must be seen if it is possible to trace the anterior border. That is easy. The anterior border sweeps obliquely downward and forward from the mid-dorsum, over the ilium, to follow the inguinal fold and reach the pubes. Opposite the outer part of POUPART'S ligament, it turns down the thigh for a short distance, just as did the anterior border of the Ist lumbar field at a slightly higher level. There is, therefore, in this position a notch downward into the posterior border of the IVth lumbar field, just as there was a shallow tongue downward from the anterior border of the Ist lumbar field. This notch may be taken to mean that the distortion of the root-field by the excrescence of the limb involves at the level of the IVth lumbar segment, not merely the posterior part of the field, but the entire antero-posterior depth of the root-field. Which is the ventral border? It is clear that the ventral border extends from the pubes below the knee along the skin covering the line of apposition of the adductor and flexor muscular groups of the thigh.

If one now, before examining the nature of the distortion of those four skin-fields in the limb that are completely detached from the trunk, examine the root-field immediately succeeding the detached fields, *i.e.*, IXth post-thoracic, it is seen that, encroaching little on the limb, the field in question is still attached to the mid-dorsal and mid-ventral lines of the trunk.

As is seen in fig. 17, Plate 48, figs. 23, 24, Plate 51, clearly the dorsal edge of the field follows the mid-dorsal line from a short distance above the root of the tail, and upon the tail, for a short way. It is also clear that the field has a ventral border at the mid-ventral line of the body from the upper edge of the anus to a few millimetres in front of the mesial end of the ischial callosity. Further, the posterior border of this field is easily distinguished as that edge of it which runs from the posterior end of the dorsal border to the posterior end of the ventral border, that is to say, partly round the half circumference of the tail, and down to the upper border of the anus. The posterior, dorsal, and ventral borders having thus been determined, the rest must be anterior border. But there is a curious character belonging to a part of the so-discovered anterior border. The border may be divided into two portions—a shorter or more dorsal portion, which passes from the anterior end of the indubitable dorsal border at the mid-dorsal line of the body on the sacrum, and extends as far as the root of the tail; and a longer remaining part, which runs from that point to the mid-ventral line of the body, and makes an angle little greater than a right angle with the dorsal part. Of these two pieces of the edge, the dorsal portion above defined does not behave as does the rest of the edge. The rest of the edge overlaps largely the skin-field of the root immediately preceding it, the VIIIth post-thoracic, and perhaps slightly the edge of the field of the VIIth post-thoracic. It behaves exactly as do the anterior borders of the root-fields examined elsewhere. The dorsal piece of the edge, on the contrary, does not lap over the field of the root immediately preceding it. It hardly overlaps any other root-field at all.

It may be truly described as coming into apposition with the root-field next it, its interlap with the root-field next it is no more extensive, or hardly so extensive as the crosslap of the fields of the right and left sides of the body at the mid-dorsum. The dorsal piece of the edge behaves as if it were a piece of the dorsal border of a field. And with what root-field does it come into contact? It comes into contact with the lowest field of those passing into the limb, but still attached to the mid-dorsum of the trunk, namely, with the skin-field of lumbar IV, a root situated five segments above it in the segmental series of the body. The intervening segments have, as it were, slipped down the limb, and left in contact the segments on either side of the gap, but those segments do not overlap in the ordinary degree of forelap and afterlap. It is natural to conclude, therefore, that the dorsal piece of what at first seems the anterior border of the IXth post-thoracic root-field does not really pertain to the anterior border, but, as regards the IXth field, is part of the mid-dorsal line. In the same way, therefore, a similar piece of what at first sight seems part of the posterior border of the skin-field of lumbar IV, is, as regards the IVth lumbar skin-field, part of the mid-dorsal line of the body.

A method by which the dorsal and ventral borders may be distinguished from the anterior and posterior borders of the segmental field consists in noting the degree to which the initial contraction of the field, followed by subsequent extension of the field, affects the various parts of its periphery respectively. The smartness of response in the field seems, as a broad rule, to which exceptions exist, to approach closer to the extreme dorsal and ventral borders, than to the extreme anterior and posterior borders. In like manner the degree in which extension of the field affects the anterior and posterior borders is much greater than that to which it affects the dorsal and ventral borders. (*Vide supra*, p. 687, and experiments on pp. 688, 689, with figs. 3 and 4.)

One is now in a better position for determining the nature of the distortion undergone by the completely detached zonal fields in the excrescence of the limb. The Vth lumbar skin-field resembles in figure an acute angled and rudely isosceles triangle, with the apex at the hallux, and the base on the front of the thigh exhibiting a deep notch in it. This notch is an exaggerated repetition of the similar notch seen in the anterior border of the IVth lumbar field. In order to determine the extent of this posterior border it is necessary to use the facts already found. One has found that in the case of the IVth lumbar field a piece of the dorsal edge turns outward over the ilio-sacrum to the thigh, that is to say, the mid-dorsal line of the body turns abruptly outward and begins to descend the outer aspect of the thigh. One has also found that the ventral border of the immediately preceding root-field, the IVth lumbar, instead of lying at the median line of the venter, lies at the median edge of the thigh, over the septum between the adductor and flexor muscle groups of the thigh. This, which may be termed the medial border of the thigh, is, therefore, as regards the segmentation of the skin, the continuation of the mid-ventral line of the body. In other words, just as at a certain point on the back the mid-dorsal line turns outward along the thigh, so at a certain point on the belly the mid-ventral line turns outward along the thigh. The crural extension of the mid-dorsal line descends along the medial border of the thigh. The true anterior border of the Vth lumbar field is now easy to determine. It leaves the mid-dorsal line of the limb at a point little more than half up the thigh, thence over the extensor muscle group, showing a deep inflexion kneeward as it does so, and finally meets the mid-ventral line of the limb on the adductor group in the most proximal quarter of the thigh. The posterior border of the Vth lumbar field sweeps from the mid-dorsal line of the limb on a level with the knee downward, over the outer aspect of the leg, and on the dorsum pedis passes lateral to the hallux (which is therefore included in the field of the Vth lumbar), and returning along the medial half of the sole of the foot ascends the groove internal to the tendo Achillis, attaining the mid-ventral line of the limb on the skin-fold over the inner hamstring tendons.

The Vth lumbar-field also helps one to extend the mid-dorsal and mid-ventral lines of the limb as low as the knee joint. The mid-dorsal line is found to descend to behind the head of the fibula; the mid-ventral line to follow the skin-fold over the inner hamstring tendons. The nature of the distortion which the Vth lumbar field has undergone is now seen to be as follows: it is a large field, but the distance between the dorsal and ventral borders of it is not so great as in the skin-fields of the thoracic roots (14 centims. as against 22 centims.). The dorsal and ventral borders are not much increased considering the large size of the field, just as in the case of the root-fields on the trunk the ventral border is longer than the dorsal. The distortion from a simple zonal shape is chiefly due to the protrusion of a great peak-shaped flap from the posterior border, which at its tip like the finger of a glove encloses the first digit. That the whole antero-posterior width of the root-field is implicated in this thrust downward is clearly indicated by the existence of the curved in-thrust of the anterior border downward corresponding to the opposite out-thrust of the peak-shaped flap.

The skin-field of lumbar VI possesses a distribution more apical than any other in the limb. The interpretation of its relation in shape to a simple zonal root-field is as follows : the anterior border passes from the mid-dorsal line of the limb at the outer side of the knee, to the mid-ventral line of the limb at the inner side of the knee. Instead of, like the anterior border of the Vth lumbar, being partially occupied by a notch, it is entirely involved in forming the sides of a huge inflexion which stretches from the level of the knee nearly to the ankle and has its retiring angle on the front of the inner face of the leg not far above the ankle joint. The posterior border of the field appears to be short, and extends from the mid-dorsal line of the limb about half-way up the thigh, across the flexor muscle-group to the mid-ventral line of the limb in the lower third of the thigh. It is not easy to determine where the posterior border joins the ventral border, partly because the line of direction of the two borders is so similar. It is also partly for the same reason not easy to determine the point at which the anterior border joins the ventral border. In fact, the exact limits of the ventral border I have not been able to satisfactorily demonstrate. Individual variation is one of the difficulties standing in the way of the determination. The dorsal border forms the most distal part of the mid-dorsal line of the limb, and extends to a little below the level of the knee. The ventral border as far as one can judge of it appears to lie not so distally on the mid-ventral line of the limb as does ventral border of the Vth. The most distal part of the mid-ventral line of the limb is therefore occupied by the Vth lumbar field, but the most distal part of the mid-ventral line of the limb is occupied by the VIth lumbar field. This is in harmony with the fact that the ventral edge of the IIIrd lumbar field is the first to leave the mid-ventral line of the trunk and run to a lateral extension of the mid-ventral line on the limb, while the commencement of the mid-dorsal line of the limb is not made until the IVth lumbar segment is reached. A means of testing the correctness of this determination of the borders of the VIth lumbar skin-field lies in delimiting the field and then determining the modification in its area produced by section of the posterior or the anterior half of the root. This I did in three experiments with the results detailed above. The object directly in view was largely frustrated by the great degree of overlap existing between the fields of the anterior and posterior halves of the posterior root. In the experiment in which the filaments composing the anterior half of the nerve-root were severed, the only result detected was an extension of the great notch on the front of the skin somewhat further down toward the ankle; that is to say, the border of the field which embraces the front of the skin certainly retreated some 2 centims. further down the limb. In the earlier of the two experiments on section of the posterior half of the root, the only result obtained was an indubitable diminution of the reflex response over the middle of the back of the ham and the middle of the top of the calf. In the second experiment there was a diminution of the reflex response from the two situations mentioned, and also the border running across the back of the thigh above the ham indubitably retreated somewhat down the limb. No other alteration were detected although carefully searched for.

In order to discuss satisfactorily the question of the segmental value of the border of the VIth lumbar root, it is here necessary to make a short digression into the action of individual variation upon the limits of the segmental skin-fields belonging to the sensory roots. Regarding the relations of the sensory spinal roots to the skin, it was shown that in *Rana* considerable Individual Variation exists. In *Macacus rhesus* I have shown that as regards the relation of the spinal motor roots to the muscles considerable Individual Variation exists. And this is true also of the sensory roots in *Macacus rhesus.* As shown in a previous paper for the motor roots this Individual Variation is based upon the segmental level of attachment of the nerve fibres to the spinal cord; some individuals possess peripheral motor nerves and muscles *postfixed* at their root attachment to the cord, while in others those structures are *prefixed* at the cord. Similarly in some individuals the cutaneous sensory nerves and skin are *postfixed,* in other *prefixed* as judged by their connection with the spinal roots.

The assertion by VOIGT (8) and KRAUSE (4), that variation only affects the course of nerve fibres, their final distribution at centre and at periphery remaining invariable, was not borne out by my study of the motor fibres, nor do I find it obtain for the fibres of the afferent roots either. If we assume that the nipple is a skin-spot identical in one individual with the nipple of another individual just as it was in a previous paper assumed that a muscle (*e.g.,* flexor brevis hallucis) in one individual is identical with the same muscle in another individual, then the nerve fibres that supply it in one individual do not always supply it in other individuals. The fibres of the IIIrd thoracic root may supply the nipple but sometimes they do not. The skin of the top of the calf is supplied in some individuals by fibres of the VIth lumbar roots, but not in all individuals by the fibres of that root. And this Individual Variation is probably of wide distribution and in minor degrees of extremely frequent occurrence. It affects the accuracy of the lines on the models prepared from my experiments, and could all those lines have been transferred from one individual only they would probably have been more regular than as now represented.

I have shown that, as regards the efferent fibres of the plexus *prefixture* and *postfixture* affect not one anterior root alone, but, usually, a number of anterior roots. In like manner, in the individual in which the field of the VIth lumbar varied from the more usual field in being dislocated from behind forwards, a similar dislocation was evident in the fields of the Xth and IIIrd post-thoracic fields of the individual. Thus, both motor and sensory roots appear within the limitation I have elsewhere mentioned to obey HERRINGHAM'S Law I. (10).

An answer is now possible to a question that has several times occurred to me during the above experimentation. A muscular point is certainly only within limits a fixed point, as regards the spinal segmentation of the body; is a cutaneous point more fixed? In view of the greater age of the posterior root and the superficial position of the skin, it might seem probable that the skin points would be less variable. Judging however from the nipple, the skin of the calf, and of the root of the tail, the fixity of the segmental level of skin points appears no greater than is that of muscular points.

Individual Variation in some ways offers difficulties to the discovery of the arrangement of the segmental skin-fields. But in one way it is advantageous, for it affords further means of assigning to their proper relations the boundaries of a root field. The root-field delimited in an individual possessing an extremely prefixed or postfixed plexus can be compared with the field delimited in individuals of less exceptional plexal construction. I have delimited the field of the VIth lumbar in six individuals, and in one of these the plexus was markedly of a postfixed type. Naturally, the anatomical condition of the plexus was not known at the time of delimitation of the field, nor was the segmental number of the root then known, for it can only be guessed at during the actual operation. Nor, as it happened, was I thoroughly acquainted, at the time of that experiment, with the limits of the VIth lumbar field, for it was only the second experiment on that field that I had made, and I was at that time unacquainted with either the Vth or VIIth lumbar fields. Fortunately, the individual with the delimitation marks on it, and also photographs taken from it, had been preserved. The difference was remarkable. From the specimen it was seen the VIth root of the extremely postfixed plexus was not distributed to the back of the ham and calf, as is the VIth root of the more usual plexus, while it was supplied to more of the front of the leg, especially of the upper peroneal surface than is the case in the more usual plexus. The anterior border lies in the postfixed field more headward (anterior), that is, less distal in the limb; the posterior border lies also more headward (anterior), that is, in the limb more distal, for it is on the posterior side of the limb-apex. If the amount of shifting from the more usual position of the posterior border, by reason of the postfixture, be compared with the amount of the shift of the border produced by section of the posterior half of the root in the two experiments above mentioned, it is found greater in the former than in the latter. The degree of postfixture, therefore, if measured in terms of the rootlets is found to be equivalent to certainly more than one-half of a lumbar segment. As regards the arrangement of efferent fibres in the lumbo-sacral plexus, in none of the species experimentally examined by me did I find the extreme limits of individual variation involve so much as a whole length of origin of one of the larger nerve-roots. The same holds true for my observations on the afferent fibres.

To return: the nature of the distortion of the VIth lumbar field is somewhat as follows. The field is a large one. The dorsal and ventral borders of it are less far apart from one another than is the case in the zonal fields on the trunk. The dorsal and ventral borders are not much enlarged considering the size of the field. The posterior border is short and curved, with a short convexity toward the leg, passes fairly directly from the mid-dorsal line of the limb to the mid-ventral line of the limb. Just as in the case of the root-fields on the lower part of the trunk, the field slopes from its dorsal border backwards towards its ventral border. In other words, just as on the lower trunk the ventral extremity of the skin field of the root lies somewhat further from the head end of the body than does the dorsal extremity of the field, so here. And one has seen that the same slant obtains in other root-fields already examined in the limb; but there is a difference between the application of it in the preceding skin fields (*e.g.*, of lumbar IV) and here, because with them the ventral extremity of the field, lying further removed from the head than the dorsal extremity of the field, lay further down the limb than the dorsal extremity; here, with the VIth lumbar root field, the ventral extremity of the field, because it lies further removed from the head than the dorsal extremity, lies higher up, *i.e.*, less distal, in the limb than the dorsal extremity. This is the fuller expression of the fact that was already indicated by the distribution of the Vth lumbar field, viz., that in the limb the essentially zonal root-fields sloping down from mid-dorsal line to mid-ventral line, are now beginning to return from the apical portion of the limb to the proximal. The return procession of the root-fields from the apex of the limb to the trunk, commences with the VIth lumbar skin-field, just as the outward procession of the root-fields from the trunk to the limb apex commences with the Ist lumbar field. And the distortion of the root-field by the excrescence of the limb, instead of affecting the posterior edge of it more greatly than the anterior (IInd, IIIrd, IVth, and Vth), now implicates the anterior edge more deeply than the posterior. Further, this VIth lumbar root-field besides being distorted has been dislocated from the side of the trunk to the extremity of the limb, or, in other words, from the middle or primary axial lines of the trunk to the distal end of the secondary axial lines, the middle lines of the limb.

The skin-field of the VIIth post-thoracic root extends over almost the whole of one aspect of the limb, as a long strip. It is, therefore, a large root-field, but it appears at first sight not so obviously distorted from the simple zonal type as are the previously described root-fields of the limb. Its dorsal and its ventral border are not extensive, considering the size of the field; they lie a much less distance apart than do the distance separating the dorsal and ventral borders of the cutaneous root-fields on the trunk. The anterior border of the field sweeps from the mid-dorsal line of the limb at a point somewhat above halfway between the knee and hip. From that point it descends over the outer hamstring and the outer head of the gastrocnemius to enter the dorsal aspect of the foot in front of the external malleolus, and passes usually to the medial side of the third digit on to the sole. On the sole it usually runs along the prominence caused by the short muscles of the hallux to reach the groove behind the internal malleolus, and thence runs up the leg on the inner head of the gastrocnemius, finally sloping into the mid-ventral line of the limb about one-third up the thigh. The posterior border is very much shorter than the anterior (about 15 centims. as compared with 47 centims.). It passes from the mid-dorsal line of the limb a little above the hip, backwards round-across the gluteal region outside the ischial callosity, to reach the mid-ventral line of the limb at the top of the thigh.

The distortion of the original simple zonal-shaped field into this figure has affected chiefly its anterior border; that border has been prolonged as a long narrow tongue thrust down the whole length of the thigh, leg, and foot, and containing the skin of the three outer digits at least. It is thus clear that the apparent resemblance of the VIIth post-thoracic skin-field to the original simple zonal root-field is of superficial character; so great is the distortion that has really occurred that what was originally the long diameter of the strip has become the short diameter, and the long strip figure of the field is caused by the development of a huge spur from the anterior edge of it.

The VIIIth post-thoracic root-field is more easily explained in reference to the relation of its borders to those of the original simple zonal field. The dorsal and ventral borders of it coincide with the mid-dorsal and mid-ventral lines of the limb, and apparently are of considerable length. The distance that separates them is about one-half the circumference of the limb. The posterior border is shorter than the anterior, as in the case of two preceding root-fields. It starts from the mid-dorsal line of the limb somewhat proximal to the point at which the VIIth root-field in my specimens started, and sweeping down over the buttock passes internal to the ischial callosity and appears in front at the side of the pubes, meeting the mid-ventral line of the limb in the most proximal part of that line. The direction of the anterior border near its junction with the mid-dorsal line of the limb is so similar to that of the mid-dorsal line itself that it is difficult to locate exactly. It seems to lie somewhere below half-way between the hip and the knee. It descends, and then ascends, enclosing a tongue-shaped flap of variable length and size upon the back of the calf; its place of junction with the crural mid-venter is difficult to determine, for the same reason as renders difficult the determination of the junction of the border with the mid-dorsal line of the limb.

The nature of the distortion undergone by the VIIIth post-thoracic skin-field in the excrescence of the limb appears to affect chiefly the anterior part of its field. A flap has protruded forward from it (that is to say *down* the limb), and the width of the base of the flap is so great as to involve the whole anterior border from mid-dorsal line of the limb to mid-ventral line of the limb. As in the case of the preceding roots the end of the tongue-shaped flap is situate about half-way between the mid-dorsal and mid-ventral lines, so that the skin of the middle line of the top of the calf and ham, like the skin of the digits, corresponds with the skin of the mid-lateral aspect of the trunk (the region of the *mid-lateral line*). *V. supra*, p. 691.

The nature of the distortion of the IXth post-thoracic root-field has been already explained. The root-fields behind it treat the middle line of the perinæum and the middle line of the under surface of the tail as the mid-ventral line of the body, showing that the vulva and anus are openings in the ventral aspect of the body, and at some distance from the posterior pole.

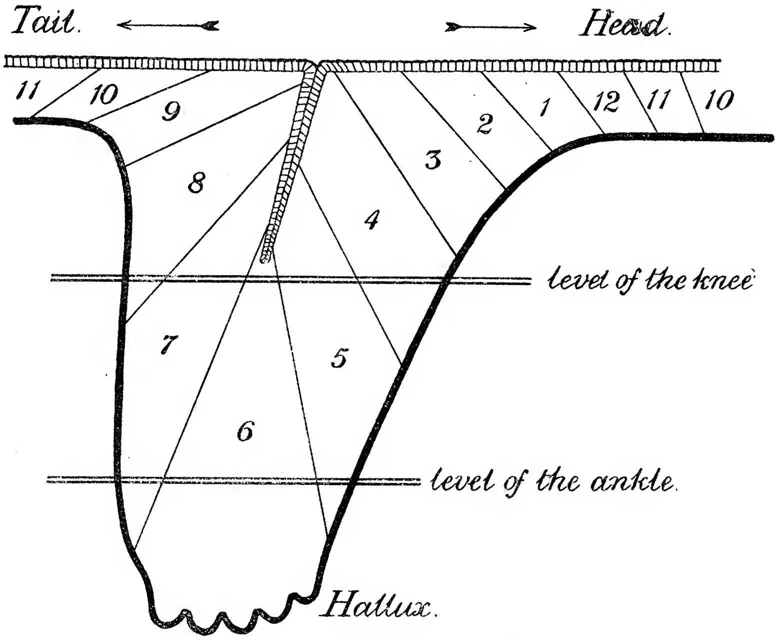
On comparing the segmental arrangement of the skin of the limb with that of the musculature of the limb, a difference becomes evident between them that is true of the fore limb as well as of the hind. I have in a previous paper shown that the limb, as regards its musculature, is composed of rays extending at right angles to the long axis of the trunk, and arranged in fore-and-aft series in such a way that the pelvic limb has a sloping anterior edge, into the composition of which enter four rays, each extending further into the limb than the ray preceding it. The posterior edge of the limb is abrupt and composed in its whole length by one ray only, the 6th, or most posterior of those which contribute to the limb musculature at all. The 5th ray like the 6th extends from the base to the free apex of the limb. A similar scheme of structure for the anterior limb is evidenced by the root supply to the musculature of it; there also the posterior border of the limb is not formed by segments extending stepwise down into it, but is abrupt and formed by the ray of the IInd thoracic segment. With this arrangement of the musculature the segmentation of the skin of the limb does not correspond. In the skin of the limb the posterior border, like the anterior border, is constituted by a series of overlapping segments and not by a single segment; and this is true of both anterior and posterior limbs alike. The segmental arrangement of skin and musculature is also different in another respect.

The motor spinal roots supplying the muscles of the limb, even those roots which penetrate farthest into the limb, all of them contribute still to the supply of the muscles of the trunk. That is to say, the segments of the limb musculature are not detached from the mid-axis of the trunk. The 5th muscular ray of the pelvic limb which contributes to the musculature of the limb in even the free apex of the limb never loses its base in the axial muscles of the trunk, and gives a share to such axial trunk muscles as the sacro-coccygeus. So also does the 6th ray.

On the other hand, at the surface of the limb the segments of the skin seem to be actually dislocated from their attachment to the dorsal and ventral axes of the trunk; they appear to be detached from the mid-dorsal and mid-ventral lines of the body. Into the base of the limb the mid-dorsal line of the body thrusts sidewise a branch, a secondary lateral axis, almost at right angles to its own direction. The mid-ventral line behaves in a like manner. These are the *mid-dorsal* and *mid-ventral lines of the limb.* Upon these secondary dorsal and ventral axes the cutaneous segments of the limb are ranged, as though upon folded portions of the axial lines of the trunk itself. It must be remembered the distribution revealed in the cutaneous fields is probably an arrangement literally *only skin deep.* The difference between the arrangement shown for the motor root and that for the sensory root may be really *less* due to the comparison being of *efferent* with *afferent* distribution, than to the comparison being of *muscle* with *skin.* From such glimpses as I have occasionally obtained of afferent fibres from muscles (*e.g.*, afferents for knee jerk, afferents of antagonistics of "jerk" muscles), these afferent fibres seem to belong strictly to the same segments as supply motor fibres to their muscles

It is interesting to note that no cutaneous branches can be found by dissection to be given from the posterior primary divisions of the Vth and VIth post-thoracic nerves of *Macacus rhesus*—at least, I have failed to find any. The muscles of the back do receive branches from the posterior primary divisions of these nerves, and in the musculature of the back the nerves end. SWAN* says of the IVth and Vth lumbar nerves of Man that the posterior primary divisions of them give off no cutaneous branches. The same is true of the VIIth, VIIIth, and sometimes VIth cervical nerves. TÜRCK (7) says that in the Dog the IVth, Vth, VIth, and VIIth lumbar nerves yield no supply to skin by their posterior primary divisions. This apparent absence of cutaneous distribution by the posterior primary divisions of these nerves is, I would suggest, a sign that they are at the very centre of the limb region —the region in which the skin segments have slipped outward down the limb. It is a point which apparently escaped ROSS (14), and is unrecognised in his suggestive essay mentioned above.

Fig. 8.



Scheme of the sensory Spinal skin-fields of the hind limb of *Macacus rhesus*. The overlapping is not indicated.

In *Macacus rhesus* to the cutaneous surface of the anterior aspect of the hind limb six segments contribute, the Ist, IInd, IIIrd, IVth, Vth, and VIth post-thoracic, to that of the posterior aspect four segments, the VIth, VIIth, VIIIth, and IXth post-thoracic; to the cutaneous surface of the posterior aspect of the fore limb five segments contribute, the Vth, IVth, IIIrd, IInd, and Ist thoracic; to that of the anterior aspect of the limb six segments contribute, the IIIrd, IVth, Vth, VIth,

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* JOSEPH SWAN, "Demonstration of the Nerves." London, 1834.

VIIth, and VIIIth cervical. There is thus a curious agreement in the number of segments contributing to the surfaces of the fore and hind limbs. And in each the anterior aspect is seen to be segmentally more extensive than the posterior, just as was found to be the case with the musculature of it.

The number of segments contributing to the skin of the limb is seen to be greater than the number of segments contributing to its musculature. From examination of the motor fibres of the lumbo-sacral plexus, it was concluded that the limb, "plastic, like the rest of the body, has been moulded by variation and by function, but not so rudely as to seriously obscure its segmental plan." The segmentation at the surface of the limb presents, as has just been shown, certain characters different from the segmentation of the deeper parts. From examination of the segmentation of the skeletal muscle of the limb, it was concluded that "the quadrifid or quinquifid digital partition of the free end of the limb does not imply that respectively four or five segments are prolonged into the apex of the limb."*

In like manner, with the cutaneous segmentation of the limb, the quadrifid or quinquifid digital partition at the end of the limb has nothing to do. The skin of the four pedal digits of the Cat belong to three of the cutaneous segments in common (VIth, VIIth, VIIIth post-thoracic). The skin of the five pedal digits of *Macacus* belong to three of the cutaneous segments in common (the Vth, VIth, VIIth lumbar). I have shown elsewhere and in the present paper that the 5th segment of *Macacus* is the 6th of Cat. The skin of the hallux, therefore, of *Macacus* is produced by an extension of the skin of the segment, which is the 6th in the Cat, and is formed by the excrescence of another digit from a segment already bearing digits, and not by the introduction of another segment into the foot.

In describing experiments on the motor fibres to the muscles of the foot and hand, I have mentioned that it is extremely difficult to get any evidence that the intrinsic musculature of the 1st digit is segmentally anterior to the intrinsic musculature of the 5th digit.† But the evidence that the skin of the 1st digit is segmentally anterior to the skin of the 5th digit is from the above experiments definite enough; the skin of hallux is shown to be segmentally anterior to skin of secundus, that of secundus to that of tertius, and so on; the skin of the dorsum of the foot is shown to be segmentally anterior to the skin of the plantar aspect.

W. KRAUSE (4) has stated that in the Monkey and Rabbit the absolutely longest fibres in the brachial nerves are those of the VIIIth cervical, which pass to the end of the 3rd digit of the hand, and SCHWALBE‡ has based his inferences regarding the size of the nerve-fibres partly upon KRAUSE'S statement.

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* SHERRINGTON, *loc. cit.*, p. 767.

† 'Journ. of Physiol.,' vol. 13, p. 744. (Professor PATERSON tells me he has by dissection succeeded in the human subject in demonstrating this interesting point by unravelling the root-components in the muscular nerves.—July, 1893.)

‡ 'Handb. der Neurologie,'

In judging these inferences it is well to remember that the Ist thoracic root also contains fibres for the tip of the digit, and that the inferences should also be applicable to the fibres of the VIth and VIIth post-thoracic nerve-roots, which in *Macacus* contains the longest nerve-fibres in the whole body.

Using the segments of the skin as a guide, it is interesting to note how clearly they demonstrate that the situation of the anus is not at the posterior pole of the body, but that it belongs distinctly to the ventral aspect of the body.

The umbilicus is placed about midway between the anterior and posterior borders of the XIth thoracic root field.

The field of the XIIth thoracic root-field also includes it, the anterior border of that field lying distinctly above the umbilicus. The Xth thoracic root-field came near to it, but did not actually include it in my delimitations.

The nipple lies about midway between the anterior and posterior borders of the IVth thoracic root field ; it is also included by the Vth thoracic root-field, and partly (probably entirely) by IIIrd thoracic root-field also.

The edge of the vulva lies in the IXth post-thoracic root-field ; the anterior, or lower portion of the edge, and the side of the clitoris, is included in the VIIIth post-thoracic root-field as well ; the posterior, or upper portion of the edge, is included in the Xth post-thoracic root-field, as well as lying well within the field of IXth root.

The anus is in the Xth post-thoracic root-field, and is included also especially at its ventral edge in the IXth post-thoracic root-field.

The scrotum and side of the penis form part of the cutaneous field of the IXth post-thoracic root. The front of the scrotum and the skin of the penis are also included in the VIIIth post-thoracic skin-field. The posterior part of the scrotum is included in the Xth post-thoracic skin-field.

The skin of the hallux is part of the VIth post-thoracic root-field, and is included also in the Vth post-thoracic root-field.

The skin of the 3rd, 4th, and 5th digits is part of the VIth post-thoracic root-field, and is included as in the VIIth post-thoracic root-field.

The Genital Flap.—In the female the skin fields of the VIIIth and IXth post-thoracic sensory roots come forward under the symphysis pubis to appear on the front of the pubic region making, right and left areas together, a low triangular field with an obtuse angle above, and the base of the figure below on two slightly prominent folds at the top of the inner border of the thigh-folds, which may be called the genital folds. This ventral extension of these sacral skin-fields may be called " the genital flap." It is a flap that has been delimited by disease or injury in man, and is figured more than once in THORBURN'S 'Surgery of the Spinal Cord.' It is also described by STARR (18), J. MACKENZIE (19), and HEAD (20). The genital flap is larger in the male than in the female Macacque, it includes the scrotum and the penis to its root. At its edge the IInd and VIIIth post-thoracic sensory skin-fields seem to meet and slightly interlap. In the male Cat it comes still more forward over the pubes, and resembles the configuration given for it in the Dog in one of the sketches left by TÜRCK (7).

PEYER (2) from his experiments on the fore limb of the Rabbit, advanced the statement that the skin overlying a muscle in the limb is supplied with sensory nerve-fibres by the same spinal nerve which contributes motor fibres to the underlying muscle. This conclusion was reaffirmed by W. KRAUSE (4). It harmonises with a "law" previously formulated by SCHRÖDER VAN DER KOLK,* that the sensory branches of a nerve that gives off motor branches always pass to that part of the joint which is moved by the muscles which the motor branches supply. V. DER KOLK'S law had reference chiefly to the distribution of the nerve trunks of limb-plexuses, and was not, by V. DER KOLK, applied to the distribution of pure spinal nerves. That in the trunk the skin overlying a muscle is supplied with sensation by the same spinal nerve as that supplying the motor innervation to the muscle is no doubt generally the case. But a fact of greater constancy is that between the anterior and posterior borders of the skin-field of a posterior root, the mid-point lies posterior to the mid-point of the muscular field of the anterior root. The cutaneous field of the sensory root lies somewhat further back than does the muscular field of the motor root. And this obliquity of mutual relationship becomes greater as the trunk is followed backwards. The cutaneous field of the VIIth thoracic sensory root covers the whole of the 7th intercostal space, and more or less of other intercostal spaces also. The skin-field of the Xth thoracic root overlies a small portion only of the 10th intercostal space, but largely the 11th space, and the 12th rib. The skin-field of the sensory root of the XIIth thoracic does not overlie its corresponding rib at all, but is altogether behind it. The skin-field of the IInd lumbar sensory root extends some distance down the front of the thigh; the motor root of that nerve innervates muscles which at lowest extend as far as the trochanter minor of the femur. The skin field of the IIIrd lumbar sensory root extends as far as the lower end of the femur; the distribution of the fibres of the motor root extends no further downwards than the upper part of the thigh. For the IVth lumbar nerve the skin field of the sensory root extends to half way down between the knee and ankle; the distribution of its motor root in no instance descends below the knee. In the Vth lumbar nerve the skin field of the sensory root descends to the tip of the 1st digit; the distribution of its motor root in no instance reaches the muscular fibres of the foot. As an outcome of the graduated descent of the limb by the spinal skin-fields, followed by their ascent on its segmentally posterior aspect (described above), when the VIIIth post-thoracic segment is reached the skin-field is found, instead of extending farther down the limb than the motor supply, to extend less far down; the former stopping short at the calf of the leg, the latter running down into the intrinsic muscles of the foot.

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* FRORIEP'S 'Notizen,' 3rd Series, iv., 129 (1847).

The maximum discrepancy in the limb between the locality of distribution of the afferent and efferent portions of the same segmental nerve seems attained with the IXth post-thoracic (Cat) and IInd thoracic (Monkey). The motor fibres of these nerves descend to the intrinsic musculature of the foot. The skin-fields of the corresponding sensory fibres lie much nearer the base of the limb, *i.e.*, posterior to the muscular field.

So, also, with the upper thoracic nerves, the discrepancy between the locality of motor, muscular, and cutaneous sensory distribution is very marked. In the case of the IInd thoracic nerve, the motor root reaches the intrinsic muscles of the hand; the sensory root does not supply the skin even so far down as the wrist. In the case of the IIIrd thoracic nerve, the motor root does not supply any of the muscles of the limb proper, but the sensory root supplies the skin of the arm as far as the elbow. In the IVth thoracic nerve, the motor root does not supply any of the muscles of the limb proper, but the sensory root supplies part of the skin upon the upper arm.

An exception of less value, and probably different significance, is instanced by the portion of the cremaster attached to the testis in the scrotum. The cremaster belongs to the IInd and IIIrd, less commonly to the IVth lumbar segments. The scrotal skin overlying it belongs to nerve-roots five segments lower down, viz., to the VIIIth and IXth post-thoracic (the Ist and IInd sacral of *Macacus*).

This leads one to remember that the anterior and posterior roots of the spinal nerves are not, when traced downwards to their correlatives in the simplest forms of the vertebrate phylum, placed at the same segmental level. In the Cyclostomata and the Selachians, as well as in some Ganoids, the posterior and anterior roots are placed alternately. I have not been able to find whether there is evidence of such alternate distribution at the time of their first origin in the Mammalian embryo. The posterior root appears to be of older structure. SCHWALBE remarks: "Es würden also die *dorsalen* Wurzeln sammt ihren Ganglien für die Beurtheilung der Segmentirung des Nervensystems von grosser Wichtigkeit sein."*

A practical outcome of the above arrangement is that especially in the lower half of the trunk, and in the anterior surface of the limb, the skin of any point will be supplied with sensory nerves from spinal roots segmentally anterior to the spinal roots whence come the motor nerves to the underlying muscle. A partial exception to this is the skin of the back of the thigh, where, owing to the re-ascent of the limb by the skin fields the supply of both skin and subjacent muscle may be from the same segmental level.

Difficulties have been encountered by the surgeon from the want of recognition of this rule.† If, for example, in a case of paraplegia, the lower level of the field of æsthesia lie at the lower border of the 11th rib, it must not be supposed that the

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* 'Nervenlehre,' p. 808.

† For a surgical instance actually applying this to the case of Man, see 'Med.-Chir. Trans.,' vol. 71, 1888. Also remarks by GOWER, 'Diseases of the Nervous System,' vol. 1, p. 559, 2nd Edition.

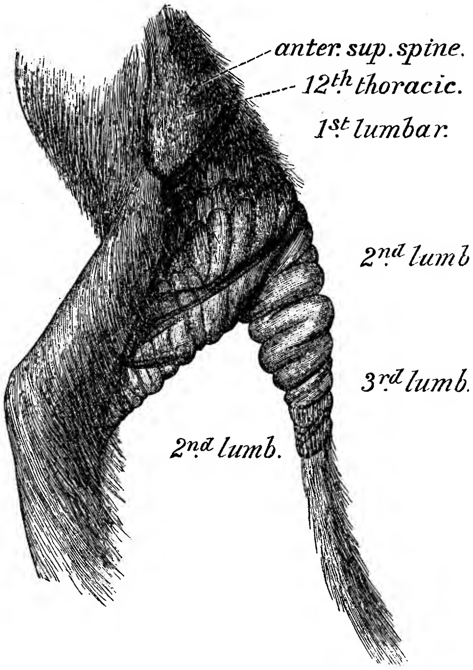
interruption of the spinal cord is situate below the origin of the XIth spinal nerve; the interruption in *Macacus* would lie under the origin of the IXth spinal nerve, or, as the above experimental fields are minimal, more probably under the origin of the VIIIth spinal nerve, that is to say, three segments higher up, and the discrepancy will be greater at the 12th rib than at the 11th, and it will be greater at the vertebral end of the rib than at the costal, for there the lower border of the 12th rib will correspond with the lower (posterior) edge of the VIIth thoracic root-field.

It is clear from the above that if coincidence of locality of nerve distribution in muscle and skin be taken as the rule, it must be applied circumspectly. The skin-field extends beyond the muscular field in a posterior direction, sometimes in an anterior direction also: VAN DER KOLK'S "law" (HILTON'S "law") is true in many places, partly by reason of its indefiniteness, a single muscular group usually causing movement at more than a single joint; partly because in regions in which the joint moved by a muscle lies segmentally posterior to the place of origin of the muscle, it will apply as the inevitable result of the above more fundamental rule of relation between overlying skin and underlying muscle. But in other parts, such as the flexor aspects of the thigh and leg and extensor aspects of the arm, it does not hold true, because there contrary to the segmental disposition of the parts. This so-called law, therefore, although imbued especially by HILTON with a teleological significance, is really a phenomenon due to the segmental arrangement of the body and possesses metameric rather than functional significance.

It must be remembered that the sensory fields delimited in the present research are cutaneous, and literally skin deep only. In such glimpses as we obtain of the distribution of sensory nerve-fibres to muscles they seem to correspond segmentally with the motor supply. To this I shall return in a subsequent paper.

By means of the pilomotor nerves it is possible to delimit in many cases fields of cutaneous distribution of the anterior root and of the sympathetic ganglion. It is interesting to inquire how far these cutaneous fields of the motor roots correspond with the cutaneous fields of the sensory root. This question may be examined in the fields of the third thoracic and highest three lumbar nerves of *Macacus rhesus*. The root territories there do not correspond. The want of correspondence is in these roots very marked indeed, so that it may happen that the cutaneous field of the one at no point coincides with the cutaneous field of the other. The pilomotor fibres of the IInd lumbar are distributed to the posterior part of the hip, buttock, upper thigh, and tail, over an area other than the cutaneous field of the IInd lumbar sensory root. The pilomotor field of the IIIrd lumbar (a field not constantly demonstrable in my experiments) lies as above and nearer the root of the tail; a region other than the skin field of the afferent root of the same segment. The pilomotor fibres in the anterior root of the IIIrd thoracic erect the hairs on the front of the scalp, but the skin field of the sensory root of that nerve is a zonal strip over the scapular and mammary regions of the chest extending down the side of the arm. As to the correspondence of the pilomotor fields of the ganglia with the skin fields of the sensory spinal roots, it was shown in a paper by LANGLEY and myself that the pilomotor fields of the sympathetic ganglia are but slightly overlapping fields. Now the overlapping of the cutaneous fields of the sensory spinal roots is one of their most characteristic features. The fields of the two cannot therefore exactly coincide, but they seem to correspond in locality though not in extent.

Fig. 9.



Area of sexual skin in a young female, *M. rhesus.*

I have looked with some interest to see whether a similarity exists between the patterns of the skin-markings of animals and the segmentation evidenced in the above experiments. Among the Monkeys commonly obtainable in this country skin-markings are largely confined to the face and buttock. Regarding the skin on the buttock of the Monkey I shall mention an observation later.

The stripes on the back and sides of the Tiger present a general correspondence with the segmental arrangement of the skin in that part, but all the structures of the body are there so segmentally arranged that it is only possible to say that the surface-markings follow the direction of the rest of the segmentation. On the buttock and thigh the direction of the skin-marks does follow the arrangement of the sensory root fields in a general kind of way, but without detailed correspondence except in the following particular. The existence of what I have called the mid-dorsal line of the limb is plainly recognizable by the skin-markings. The stripes start from and meet on a line which, in position and length, corresponds with the mid-dorsal line of the limb described above. Below the knee the striping largely fails, and such as is present tends round the leg in a ring-like fashion. The correspondence there is wanting.

The skin stripes of the Zebra follow the segmental arrangement on the trunk and neck, and exhibit the peculiarity of being boldly continuous across the mid-dorsal line. It is therefore interesting that the arrangement of the cutaneous stripes on the haunch differs from that of the Tiger in also passing boldly across the haunch, that is to say, bears the same relation to the mid-dorsal line of the limb as on the trunk and neck do the stripes there to the mid-dorsal line of the body. The stripe on the shoulder of the Ass corresponds with the mid-dorsal line of the fore-limb.

After from experiment becoming acquainted with the limits of the cutaneous fields of the VIIIth, IXth, and Xth post-thoracic roots, I was, on observing a female specimen older than most of those I had worked with, struck by the close resemblance between the shape of the region of semi-erectile skin on the limb which flushes during the menstrual period (fig. 9) and that of the combined areas of the VIIIth, IXth, and Xth nerves. The correspondence appears curiously accurate, and I would suggest that the pattern of this region of sexual skin is segmental, and connected with the relation of VIIIth IXth and Xth post-thoracic sympathetic ganglia to the skin, and of the VIIIth IXth and Xth post-thoracic roots to the sexual organs.* It is true that in the fully mature females the area of sexual skin seems to vary somewhat in extent. I have seen it descend the calf to the outer edge of the tendo Achillis above the heel; but this is to my mind no argument against, but rather one for, the connection I suggest, as though I have met no instance, I cannot but think that when the plexus is postfixed the skin above the heel may be included in the region of the VIIIth root. I should imagine that it would have been found to do so in the very postfixed specimen of which the VIth post-thoracic skin-field was determined. The photographs of the specimen almost prove that in it the VIIIth post-thoracic skin-field did descend to behind the outer malleolus, because that skin is not included in the VIth root, and therefore, to possess a double root supply as the skin of the limb everywhere does, must have received the filaments of the VIIIth as well as the VIIth. If this explanation of the position and figure of this area of sexual flushing is correct, the phenomenon would fall into the same category as the association of the distribution of somatic pain to the distribution of splanchnic sensory irritation, as sketched by Ross in his essay (16), and further developed by J. MACKENZIE (19) and by HEAD (20).

If the above flushing really be, as suggested, of visceral and reflex origin, it suggests the existence of vasomotor nerves to the skin in question from the VIIIth and IXth roots, the hind limb would obtain vasomotor nerves from two regions of the spinal cord, the lower thoracic, and upper lumbar roots as determined by ROSE BRADFORD and BAYLISS,† and from the sacral roots as well. I am not sure that this sexual flushing is confined to the female Macacque, but it is more marked in her than in the male. Mr. HEAPE, a high authority on the subject, writes to me that some males show it well.

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* See note on p. 761.

† ARRIS and GALE Lecture, 1892. *Cf.* also OSTROUMOFF, 'PFLÜGER'S Archiv,' vol. 12, p. 261.

This communication is unfortunately long. It seems therefore desirable to again epitomize some of the main results of the experiments as a conclusion.

Although in a plexus each posterior spinal root gives separate contributions to several nerve-trunks, the cutaneous distribution of the root is composed not of patches which are disjoined but of patches which are so joined that the distribution of the entire root forms one continuous field. Similarity of the root composition of neighbouring nerve-twigs that are near their destination is a necessity of this arrangement. Thus the dorsal collateral digital nerve on the tibial side of a digit will resemble in root composition the plantar collateral digital on the tibial side of the same digit, although they are derived from separate parent trunks. The dorsal digital nerve entering the cleft between the first and second toes, is interpolated in the digitals from the musculo-cutaneous trunk, although it comes itself from the anterior tibial trunk. Yet by its root composition it falls into perfect series with that of the other digital nerves.

The field of skin belonging to each sensory spinal root may be called the *sensory spinal skin-field* These fields are segmentally arranged and do not present the same variety of configuration presented by the fields of peripheral nerves. In each spinal field reflex reaction is less easily elicitable near the edge of the field than the field elsewhere.

Each sensory spinal skin-field extends to a certain extent across the neighbour skin-fields. Each has an *anterior overlap* extending into segmental fields anterior to it, each a *posterior overlap* into fields posterior; each has also *crossed overlaps* trespassing into the fellow field of the opposite lateral half of the body, both at the mid-dorsal (the *dorsal crossed overlap*), and at the mid-ventral line (the *ventral crossed overlap*). The fore and aft overlaps are throughout the body very great, and it appears that each point of skin throughout the body is supplied by at least two sensory spinal roots, in certain regions by three. The overlap of the skin-fields of the separate filaments of a posterior root is very great indeed, at least in some cases.

The shape of a sensory spinal skin-field is, where simplest, *e.g.*, in the trunk and neck, a band, wrapped transversely round one lateral half of the body with fairly parallel borders, but somewhat wider near its ventral than at its dorsal end. In the limb the segmental skin-fields are distorted from the simple band-form. The distortion of each segmental field in the hind limb and of some in the fore limb is in the foregoing paper analysed, and for each the true anterior border, the true posterior border, and the true dorsal and ventral borders are found. This analysis is only possible after it has been recognized that in the limb the cutaneous segments are not only distorted, but are seemingly dislocated from the primitive position of attachment to the mid-dorsal and mid-ventral lines of the trunk. The mid-dorsal line of the body may be said, in the region of the limb, to extend outwards as a side branch, a secondary axis, almost at right angles to the rest of itself. Similarly in the same region the mid-ventral line. Upon these dorsal and ventral side-lines, as upon secondary dorsal and ventral axes, the cutaneous segments of the limb are ranged, as though upon folded portions of the axial line of the trunk itself. The position of these secondary axes having once been found (as described above, pp. 743, 749) in the limb, it is not difficult to examine the degree of dislocation and distortion undergone by each segmental field.

In the segmentally anterior aspect of the limb each segmental field has been curved so as to present a very convex posterior edge, and the posterior *overlap* of the field is very large. In the segmentally posterior aspect of the limb each segmental field has been curved so as to present a very convex anterior edge, and the anterior *overlap* of the field is very large. The dorsal and ventral borders of the fields are, in the limb, not much increased in length.

Owing to their serial arrangement along the mid-dorsal and mid-ventral lines of the limb, there is an axial crossed overlap of the fields there of such a kind that a segmental field may there crosslap with a segmental field far removed from it in the segmental series, *e.g.*, IXth post-thoracic with IVth post-thoracic.

The dislocation of certain of the segmental fields in the limb so as to lie parted from mid-dorsal and mid-ventral lines of the body is apparent rather than fundamental in character; it is wanting even in the pelvic limb of *Rana*.

The absolute segmental level of a point of surface is subject to Individual Variation, just as that of muscular points in the body-wall and viscera. This Individual Variation affecting the skin is correlated with variation in the constitution of the afferent spinal roots, so that the limb plexus may be *postfixed* or *prefixed* by its sensory roots just as it may be by its motor roots. A mixed nerve may be postfixed by its motor roots and by its sensory roots in the same individual, or may be prefixed by both. There is some evidence (Frog) that a plexus may be prefixed by its motor roots when it is not so by its sensory roots, and *vice versâ*.

Position on the limb of the *axial lines* of the limb (Plate 51, fig. 19):—

Upon each limb exists a *mid-dorsal line* and a *mid-ventral line* branching from the *mid-dorsal* and *mid-ventral lines of the body* and almost at right angles to those latter. The axial lines for the hind limb slope outward from the middle lines of the body somewhat backward as well as outward; those for the fore limb conversely slope somewhat forward as well as outward. The *mid-dorsal line* in the hind limb runs from the mid-dorsal line of the body over the sacrum past the back of the hip joint, and along the outer face of the thigh nearly to the knee. Of the *mid-dorsal line* of the fore limb only the most proximal part is described by the present experiments; that part runs from the mid-dorsal line of the body outwards and forwards over the infraspinous scapular fossa. The *mid-ventral line* of the hind limb runs from the front of the body of the pubes to the inner border of the thigh and descends on the gracilis fold nearly to the knee. The *mid-ventral line* of the fore limb is, in the present experiments, only followed for its proximal part; that part lies on the chest close below the clavicle.

Using the cutaneous fields as a guide to the morphological position of various points in the body, it is seen that the edges of the foot and hand with their digits lie in the spinal skin-fields of the limb about midway between the mid-dorsal and mid-ventral lines, and therefore correspond with the *mid-lateral line* of the trunk (p. 691). The digits are therefore buds from the region of the *mid-lateral line,* and the preaxial and postaxial borders of the limb lie also in the mid-lateral line of the body.

From the motor roots it is not easy to get evidence that the 1st digits of the foot or hand is segmentally anterior to the 5th digit; the root supply of the intrinsic musculature of each is so similar. But from the sensory roots it is easy to show that the skin of the 1st digit is segmentally anterior to that of the 2nd digit, that of the 2nd to that of the 3rd, and so on. The skin of the dorsum of the foot is shown to be segmentally somewhat anterior to the sole.

The number of segments entering into the composition of the skin of the limb is seen to be greater than the number of segments contributing to its musculature. To the anterior aspect of the fore limb six segments contribute (IIIrd, IVth, Vth, VIth, VIIth, VIIIth cervical); to that of the hind limb six segments also (Ist, IInd, IIIrd, IVth, Vth, and VIth post-thoracic). To the posterior aspect of the fore limb four segments contribute (Ist, IInd, IIIrd, IVth thoracic); to that of the hind limb four segments also (VIth, VIIth, VIIIth, IXth post-thoracic).

In each limb the preaxial border is segmentally more extensive than the postaxial. I have shown that this last fact is exemplified even more strikingly in the musculature of the limb, both fore limb and hind limb.

The quadrifid or quinquifid digital partition of the free end of the limb is no indication of the number of segmental skin fields in the limb.

The distribution of the fibres of the sensory spinal root in the limb, as elsewhere, indicates a segmental significance in their constitution rather than a functional based on co-ordination. Without denying the existence of functional factors in the progressive development of the limb, it must be admitted that there is little evidence that the collection of fibres in each sensory root has resulted from an assortment of the fibres with a view to assisting toward functional co-ordination.

PEYER's statement of the identity of the muscular and cutaneous distributions of a spinal nerve does not bear minute examination. The IInd thoracic nerve may innervate the intrinsic muscles of the hand, but its skin-field does not reach the hand at all. In the lower half of the trunk and in the pelvic limb, the skin at any point tends to be supplied by sensory spinal roots segmentally anterior to (higher than) the spinal motor root supplying the subjacent muscle. A partial exception to this will be in the skin of the back of the thigh, where, for reasons above explained, the supply of both tends to be from more truly parallel segmental levels.

The cutaneous fields of the sensory spinal roots do not correspond closely with the fields of distribution of the motor roots in the skeletal muscles, nor do they correspond with the fields of cutaneous distribution of the motor roots as judged of by the pilomotor fibres of those roots, but the pilomotor fields of the sympathetic ganglia and the cutaneous sensory fields do correspond.

In *Macacus rhesus* there seems a close topographical correspondence between the area of sexual skin at the root of the tail, on the buttock, and along the back of the thigh and the combined sensory skin-field of Xth, IXth, and VIIIth post-thoracic roots.

I wish in concluding to mention my indebtedness to Professor MICHAEL FOSTER for opportunities and counsel freely given upon several occasions. I would also thank my friends Dr. ROSE BRADFORD and Dr. HENRY HEAD, the former for largely suggesting the research, the latter for instituting comparison between the experimental areas dealt with in this paper and his own extended clinical observations of a somewhat converse nature. [To Professor PATERSON and to Dr. JAMES MACKENZIE I am very greatly indebted for criticism afforded when these pages were passing through the press. Two diagrams, on Plate 52, were kindly sketched for me by Professor PATERSON.]

[NOTE.—June 12, 1893. LANGLEY'S observations on the sympathetic system lead him to conclude that the cutaneous distribution of the pilomotor and secretory fibres arising in a sympathetic ganglion is the same as the cutaneous distribution of the sensory fibres arising in the corresponding spinal ganglion.* In testing the point, he suggests for comparison with the sensory skin-fields of the limb the secretory nerves (post-ganglionic) of certain ventral cutaneous branches running to the hind foot. I had tentatively delimited the skin-fields for the hind limb of the Cat some time since when examining the account given of the Dog by TÜRCK. After reading Mr. LANGLEY'S paper I have repeated the experiments with special attention to his point, using, as before, the method in Experimental Series No. II. In the *pad* and *cushions* of the hind paw the fields of the VIth, VIIth, and VIIIth post-thoracic spinal ganglia were compared with the fields of the corresponding sympathetic ganglia as revealed by post-ganglionic sweat-fibres, and figured in LANGLEY'S paper. The agreement of the fields was found to be close; it may be exact, but the sensory fields as actually delimited were rather less extensive than the sweat fields figured. Once only in five experiments was a contribution from the IXth post-thoracic sensory root detected; where it existed the contribution closely agreed with the corresponding sweat field figured by LANGLEY. The results accord, therefore, with LANGLEY'S conclusion, which, sufficiently interesting in itself, is the more important as from it he proceeds to further generalisation.—C. S. S.]

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* 'Journ. of Physiology,' vol. 12, p. 347; 'Roy. Soc. Proc.,' vol. 52, p. 547.

EXPLANATION OF PLATES 42–52.

In Plates 42, 43, 44, 45, and 46 the *field of response* (see pp. 649 and 688) is limited by a double line of white and black; the white side of the line lies toward the *field of response*, the black toward the surface whence no response was elicited.

PLATE 42.

Fig. 1. The IInd thoracic field, with posterior edge of IVth cervical, and anterior edge of VIIth thoracic.

Fig. 2. The IIIrd thoracic field, with posterior edge of IIIrd cervical, and anterior edge of VIIth thoracic.

PLATE 43.

Fig. 3. The IVth thoracic field, with posterior edge of IIIrd cervical, and anterior edge of VIIth thoracic.

Fig. 4. The VIIth thoracic field, with posterior edge of IVth thoracic, and anterior edge of Xth thoracic.

Fig. 5. The IVth thoracic field, with the anterior edge of the VIIth thoracic.

PLATE 44.

Fig. 6. The IIIrd post-thoracic field, the posterior edge of the XIIth thoracic, and the anterior edge of the XIth post-thoracic. The position of the last ribs is marked.

Fig. 7. The Ist and Vth post-thoracic fields, the posterior edge of the Xth thoracic, the anterior edge of the XIth post-thoracic.

Fig. 8. The XIIth thoracic and IVth post-thoracic fields, and the posterior edge of the IXth thoracic. Position of the lowest ribs is marked.

PLATE 45.

Figs. 9 and 10. The VIth post-thoracic field.

Fig. 11. The IIIrd and IXth post-thoracic fields, with the posterior edge of the XIth and XIIth thoracic, and anterior edge of XIIth post-thoracic. Position of lowest ribs is marked.

PLATE 46.

Fig. 12. The Vth post-thoracic field.
Fig. 13. The VIth post-thoracic field.
Fig. 14. The VIIth post-thoracic field, posterior edge of IIIrd, posterior of Xth post-thoracic.

PLATES 47, 48, 49.

Figs. 15-19 inclusive. Skin-fields from the IVth thoracic backwards, shown on a plaster cast of a young *Macacus rhesus.* The *mid-dorsal line of the limb* is marked in on the left thigh in fig. 19.

PLATES 49, 50, 51.

Figs. 20–24 inclusive. Similar plaster cast. The anterior borders of the skin-fields are marked on the left half of the cast, the posterior borders on the right half.

PLATE 52.

Diagrams to illustrate the arrangement of the skin-fields, and the terms used in the description.

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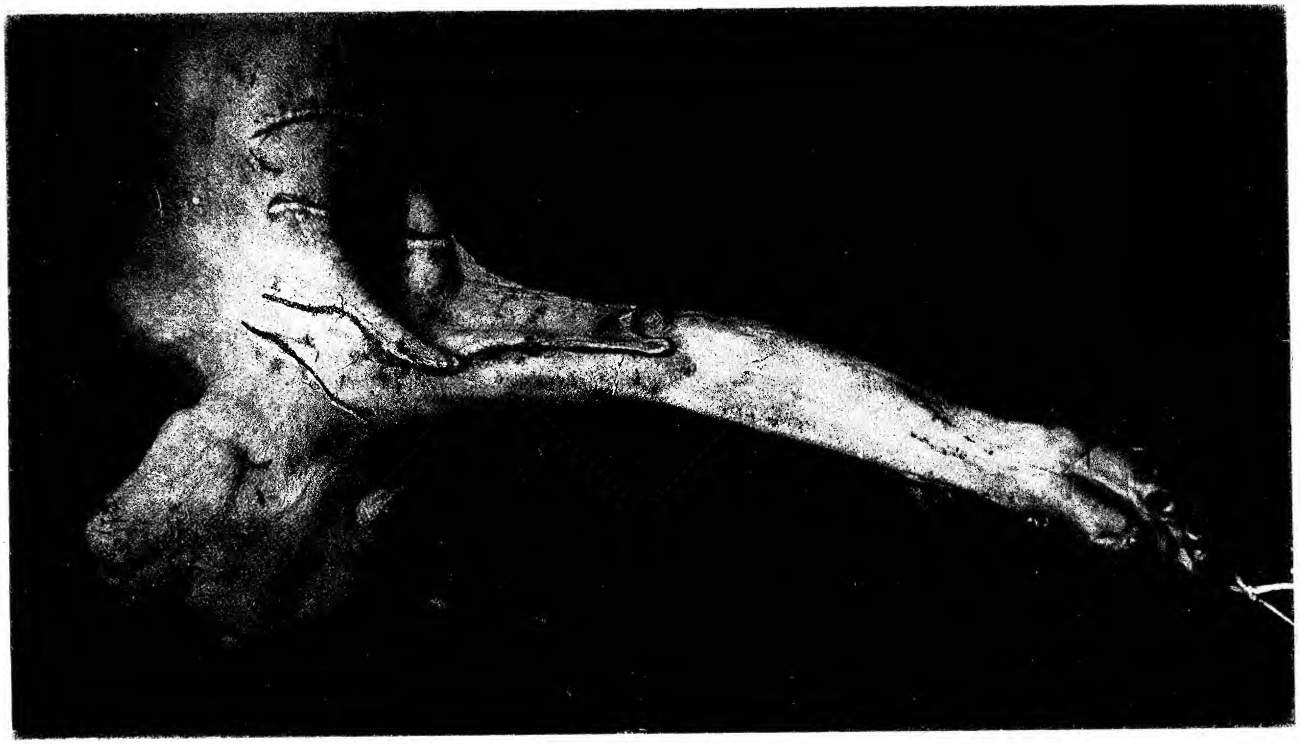

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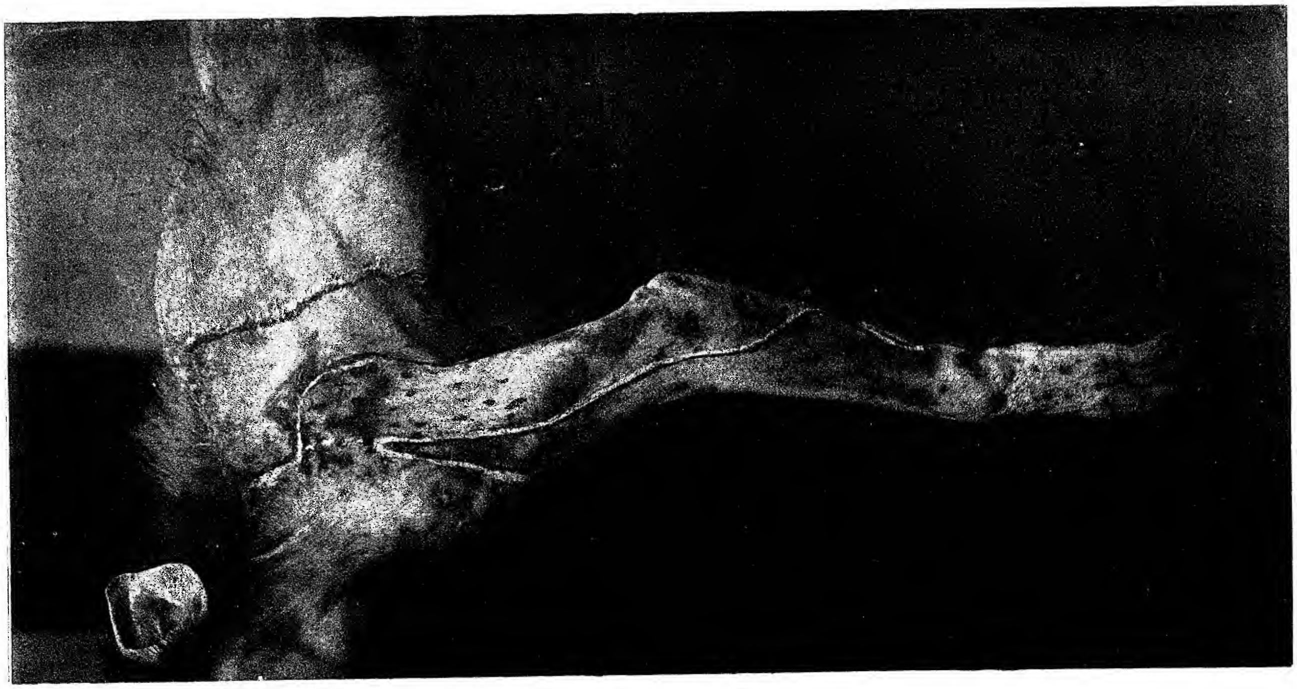

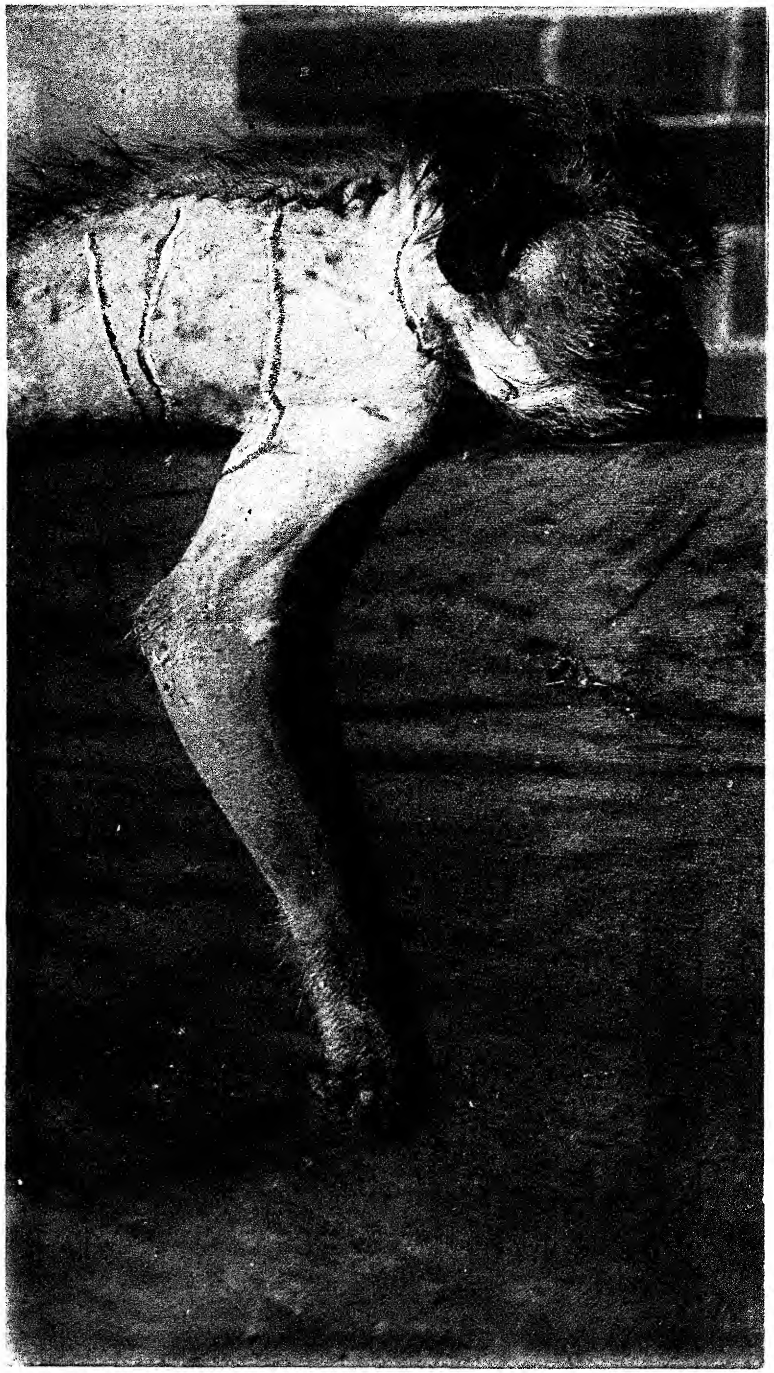

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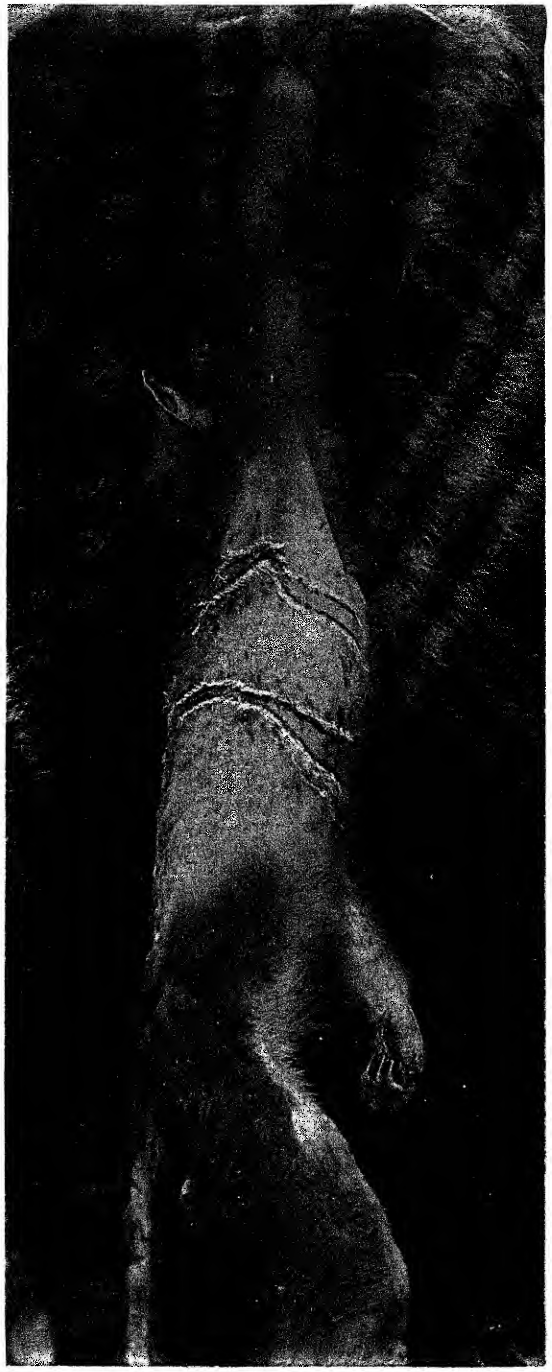

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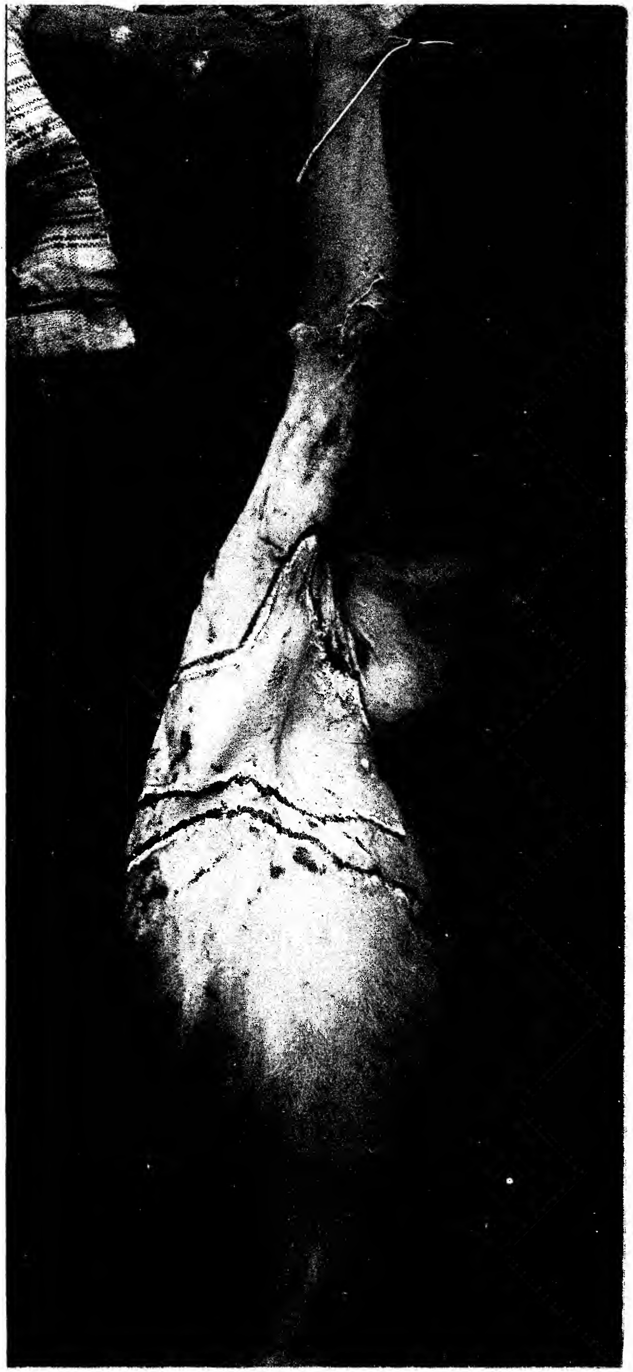

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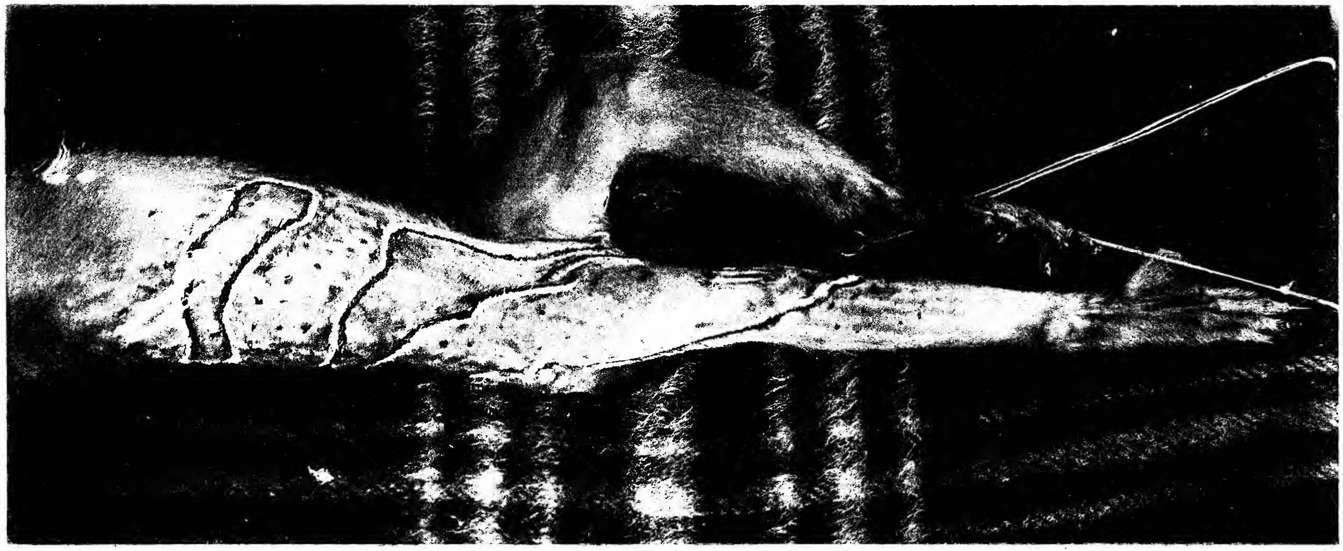

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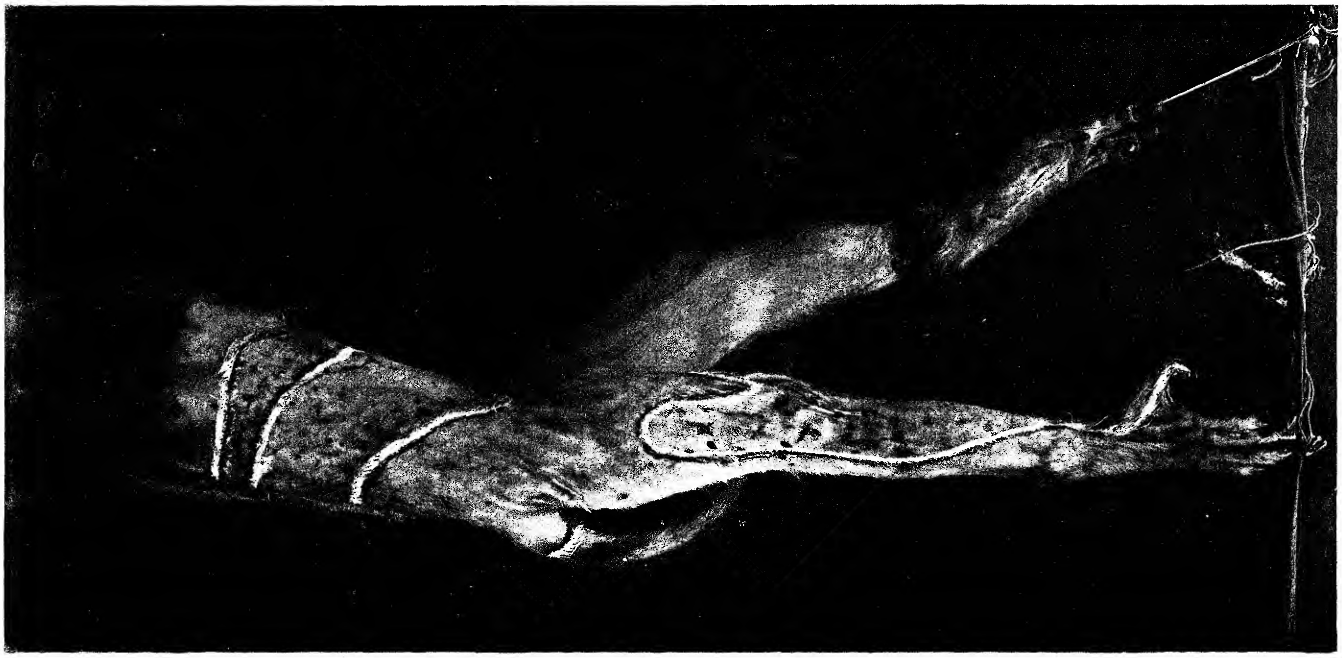

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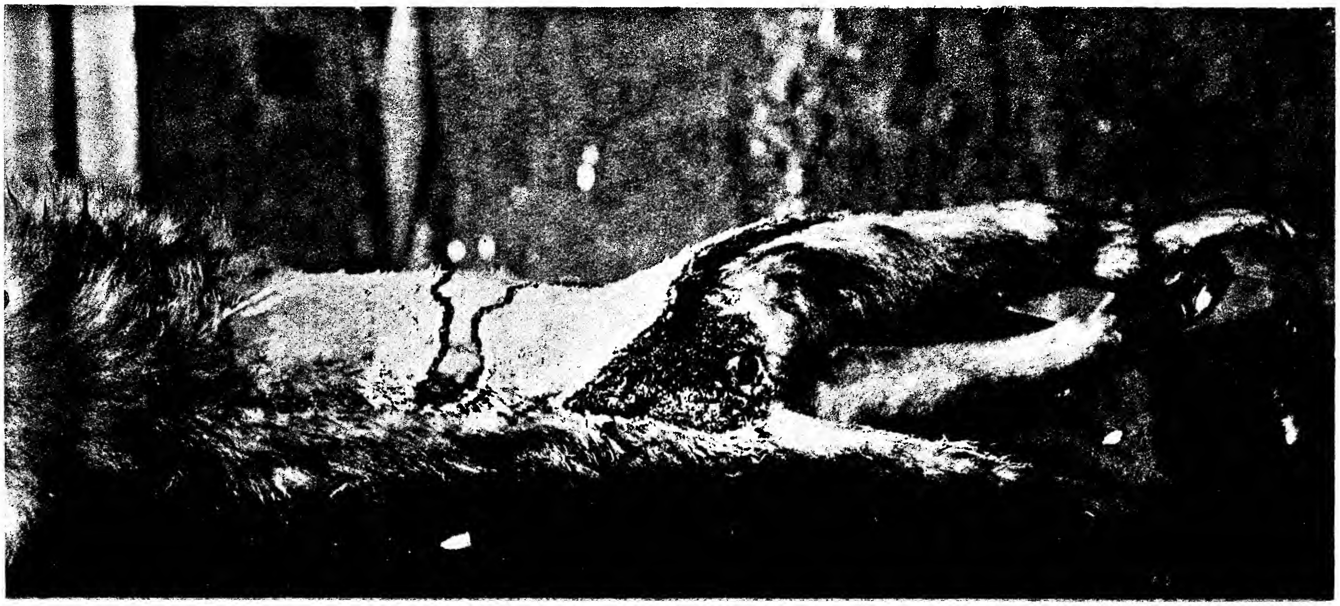

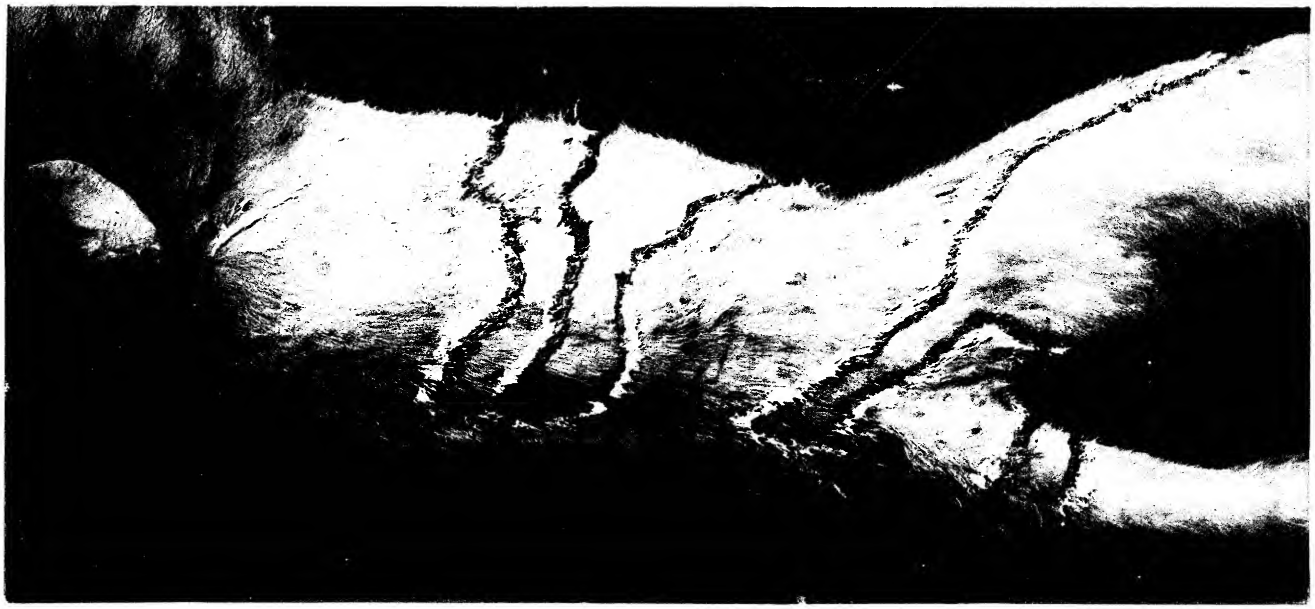

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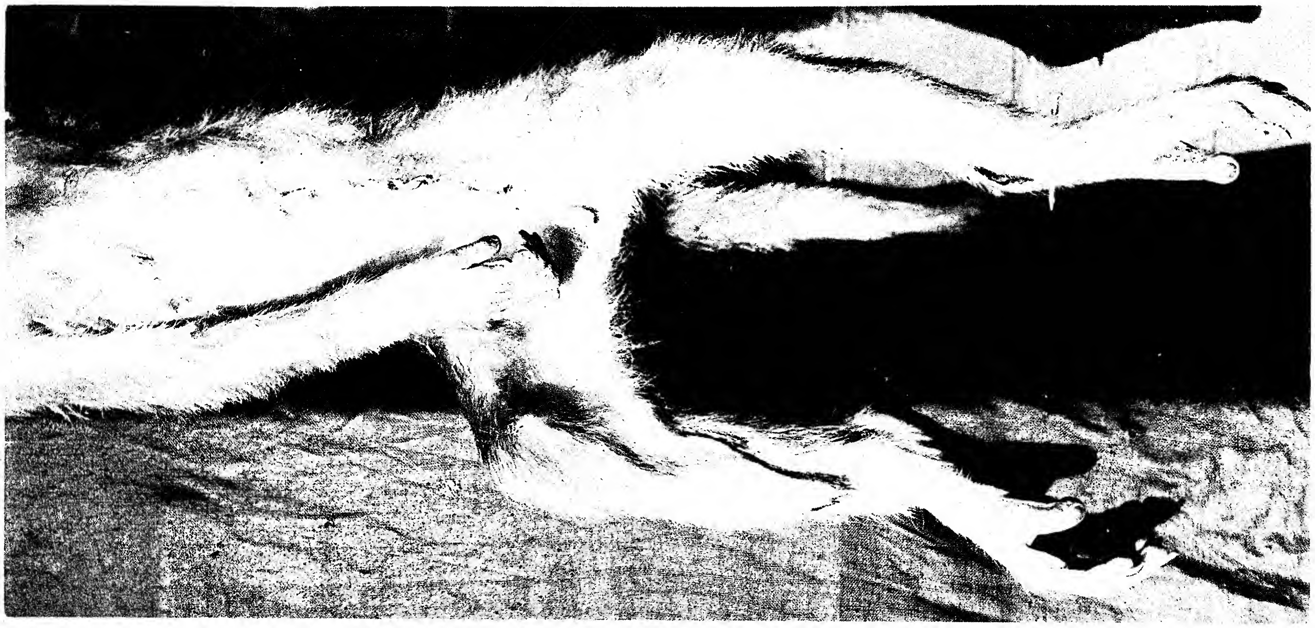

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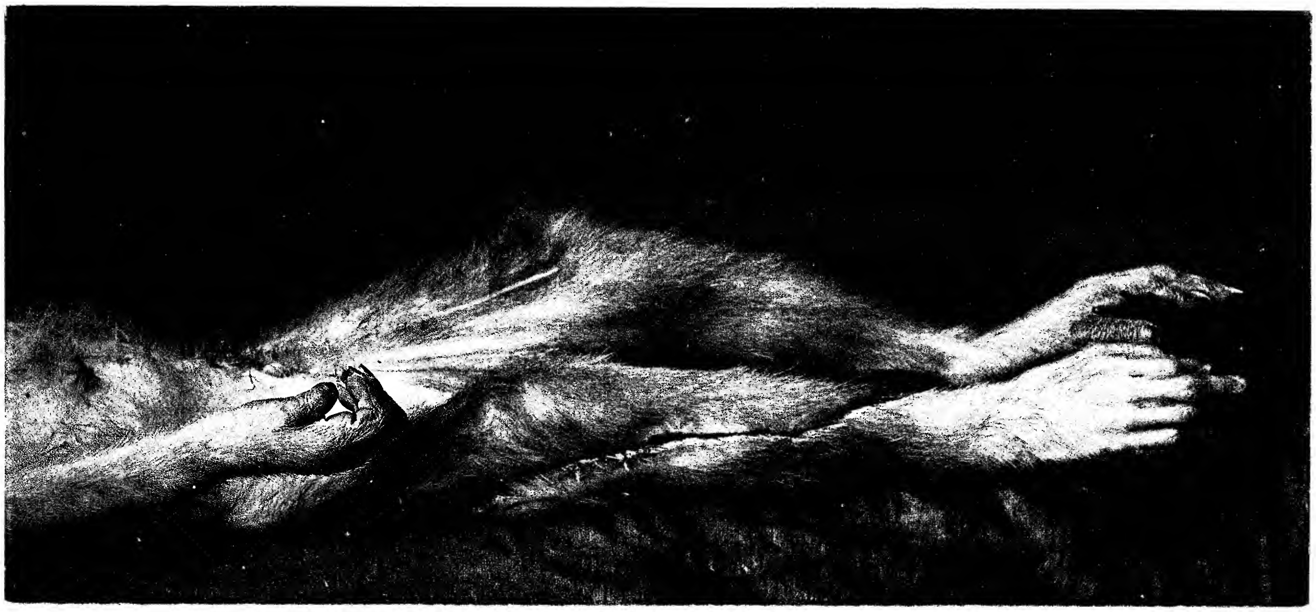

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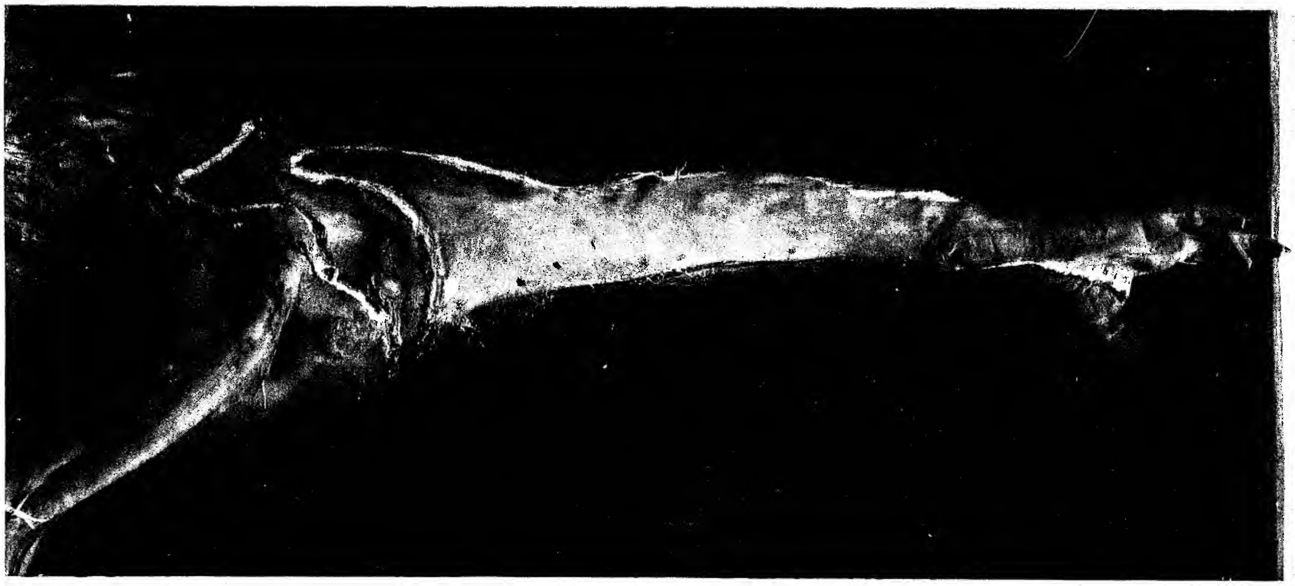

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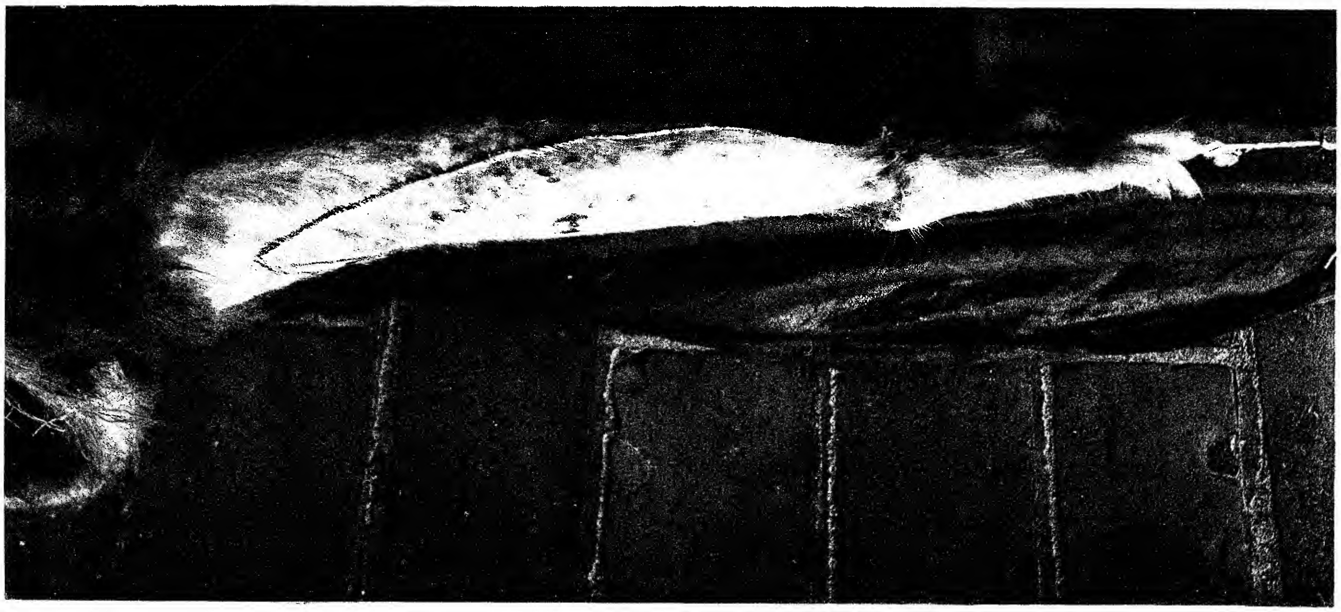

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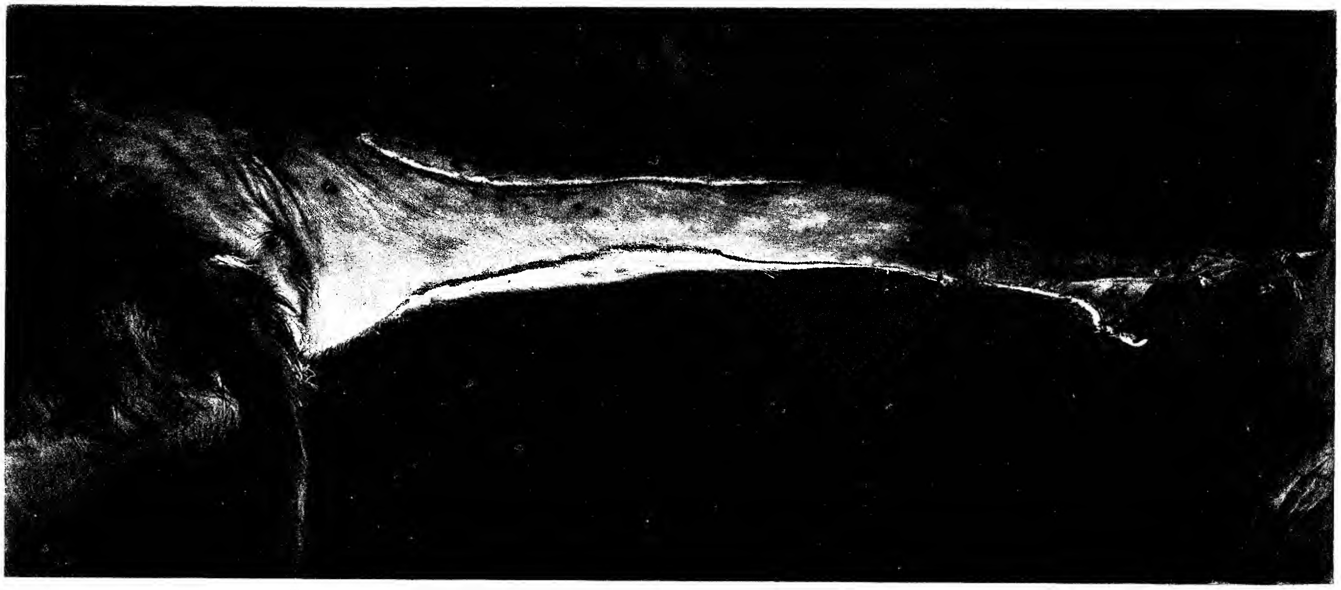

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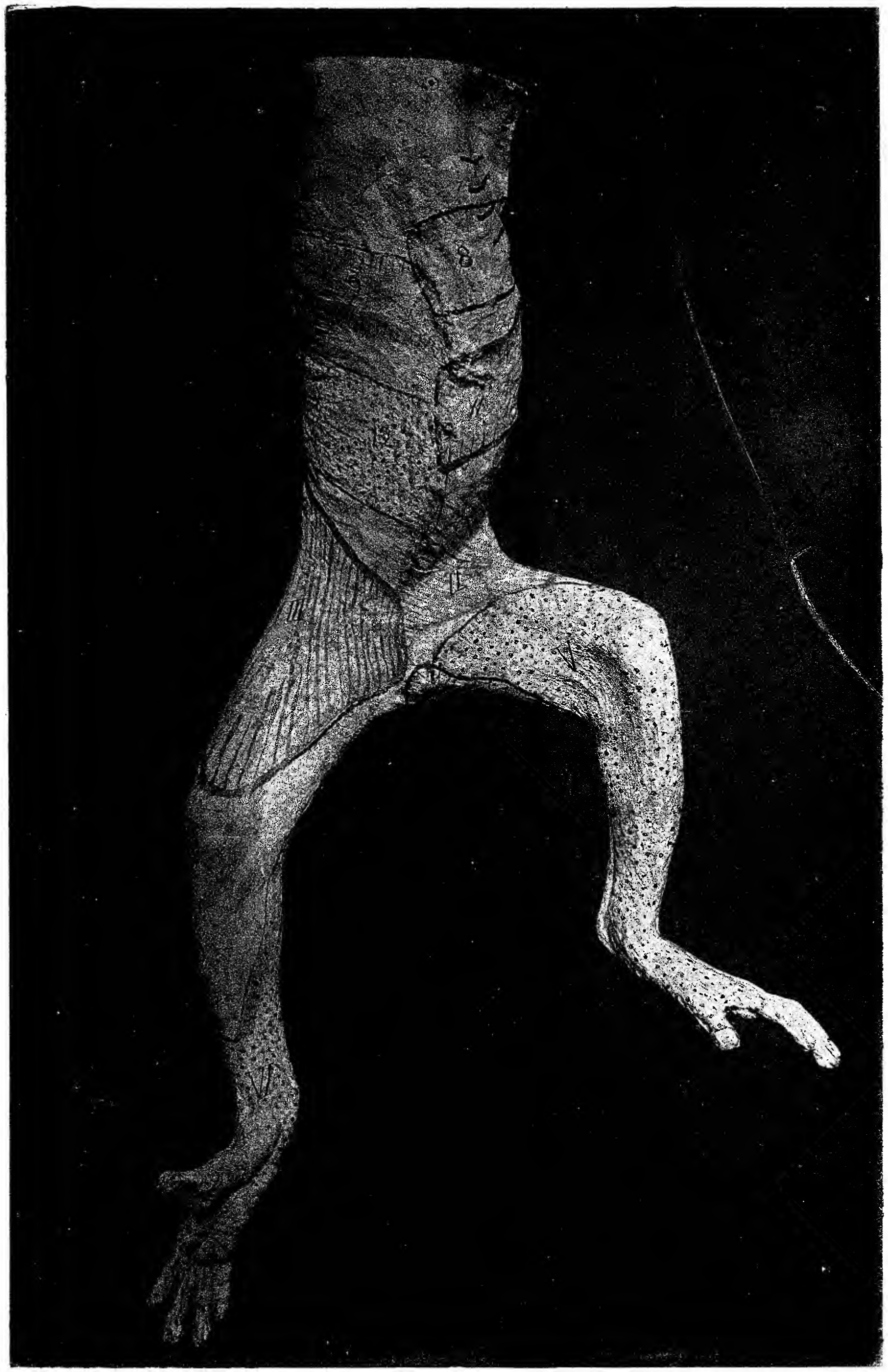

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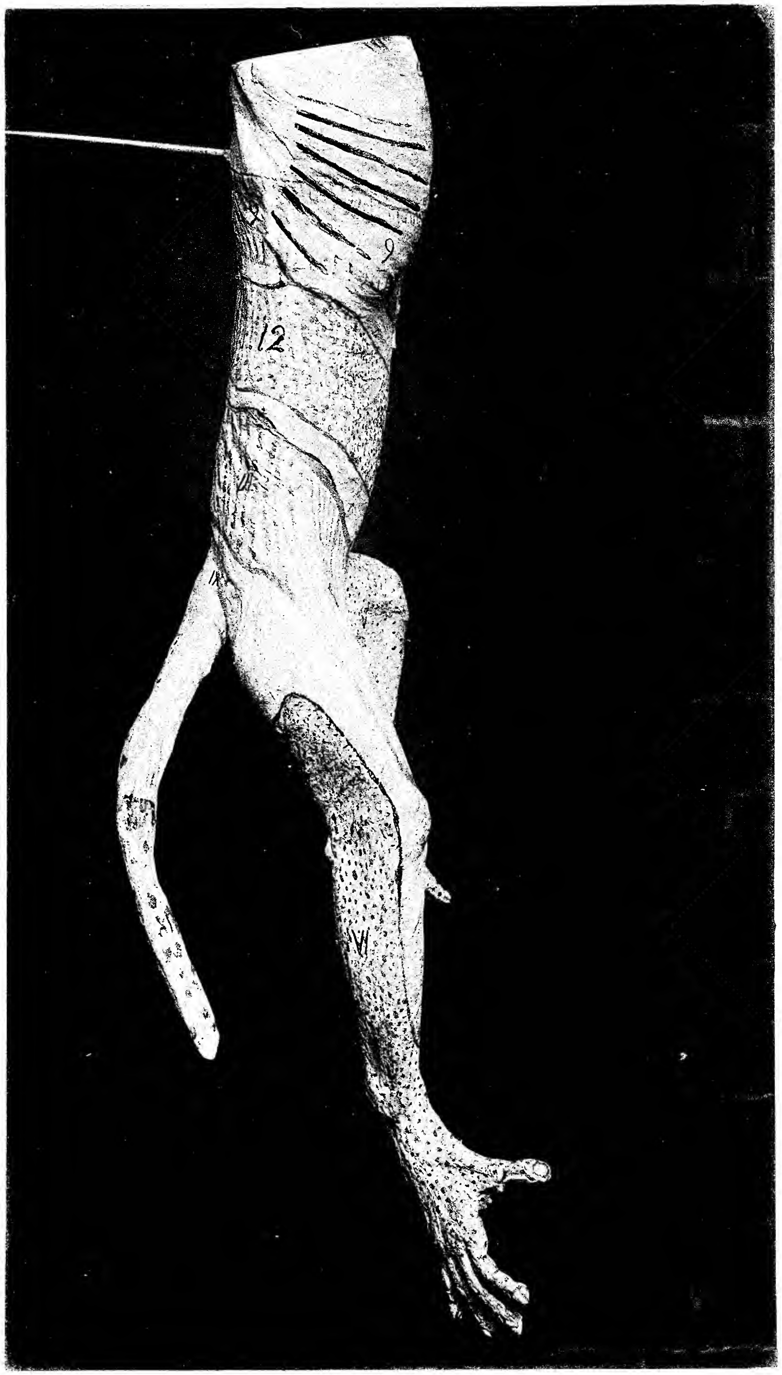

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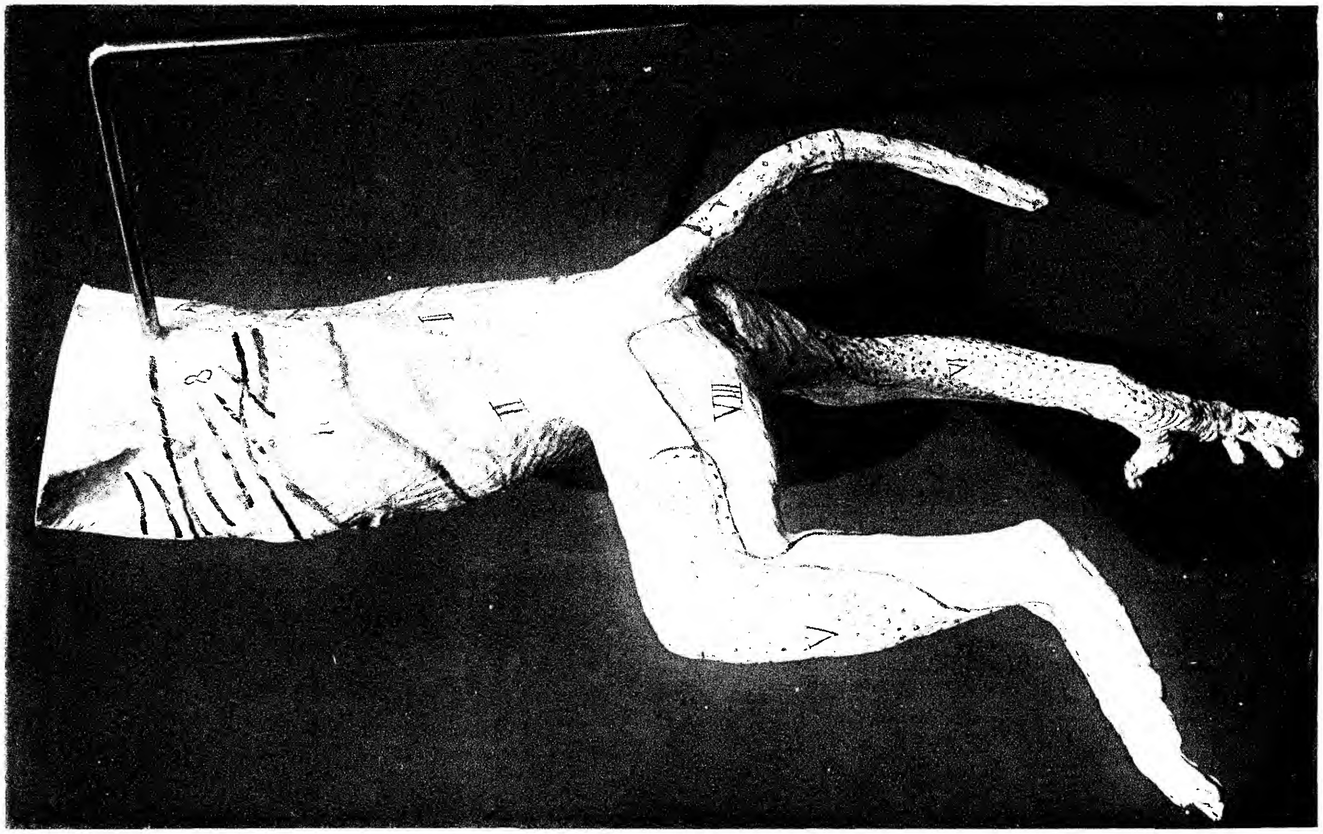

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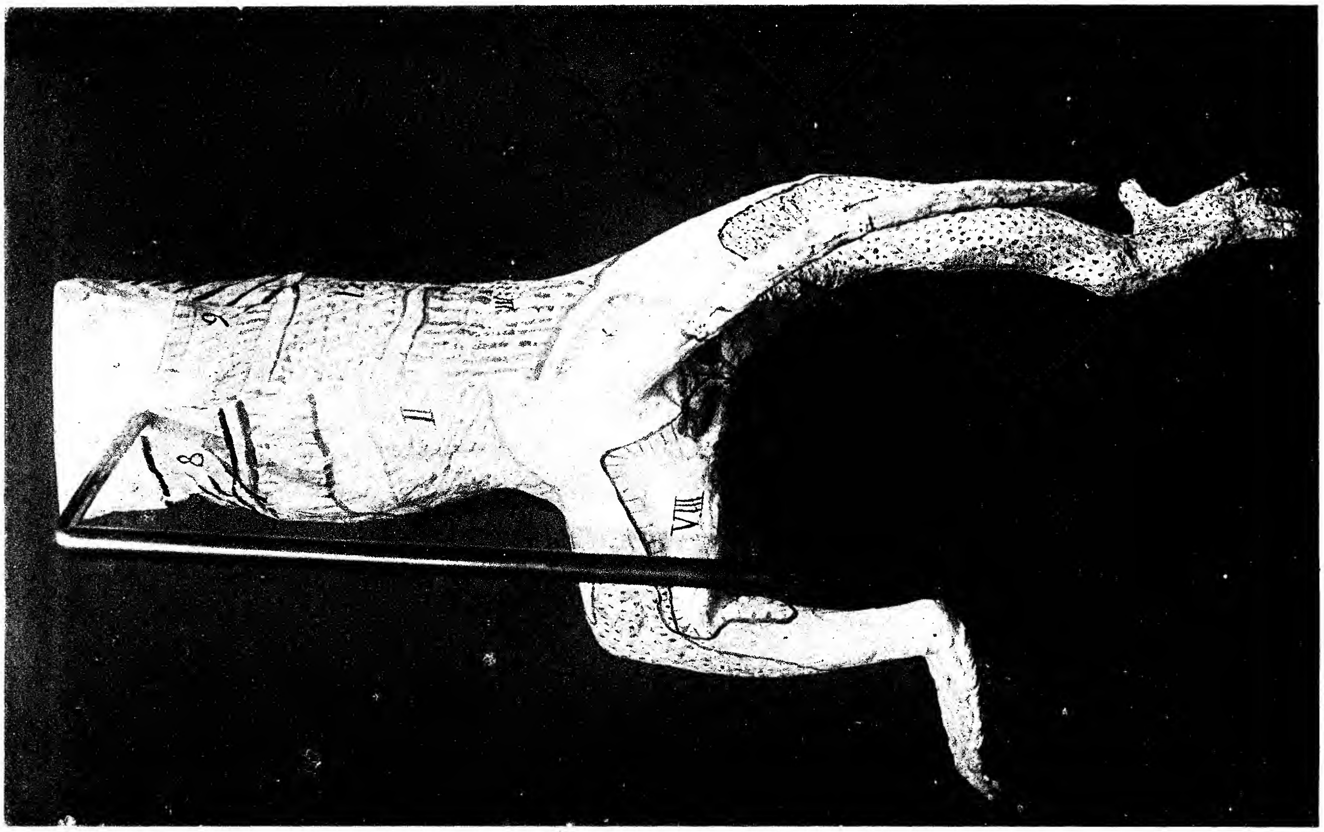

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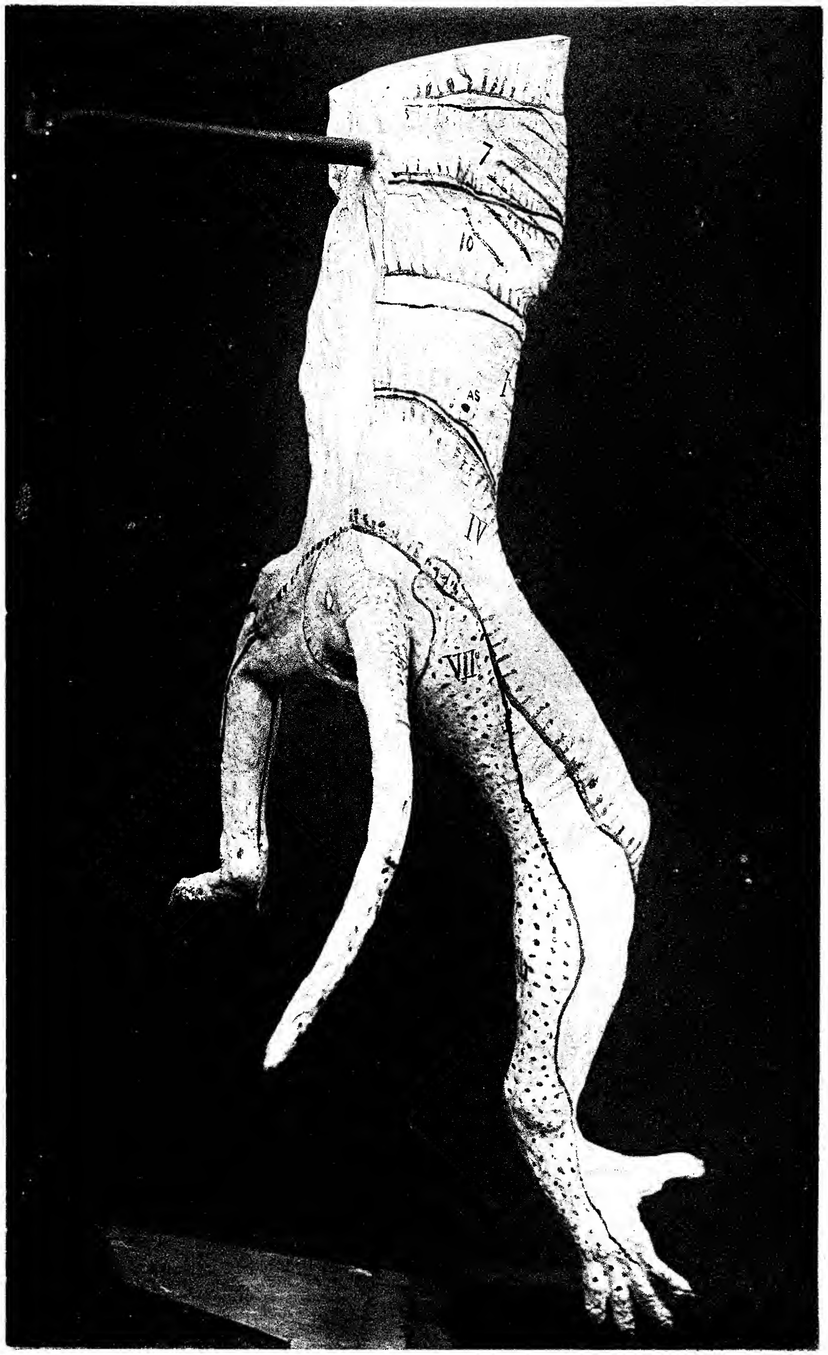

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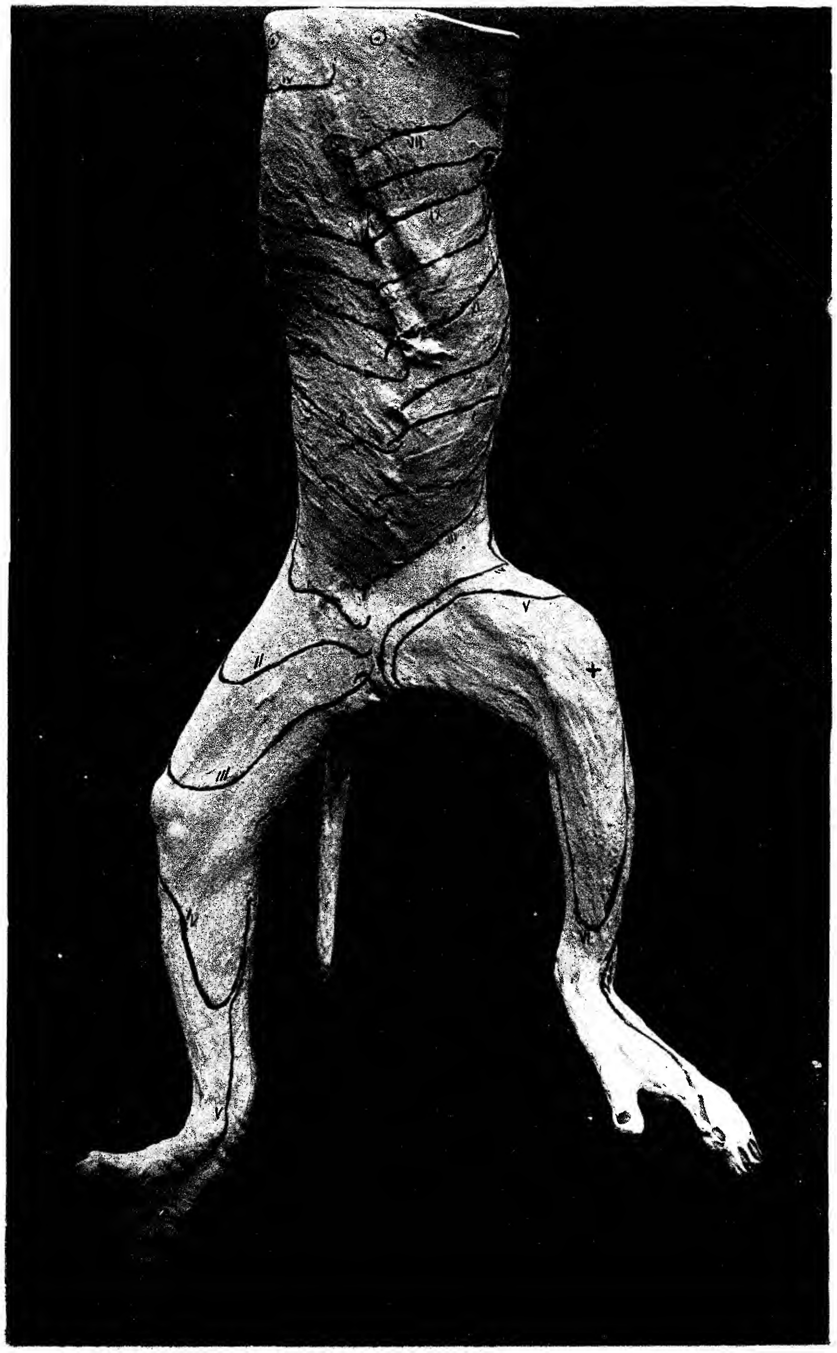

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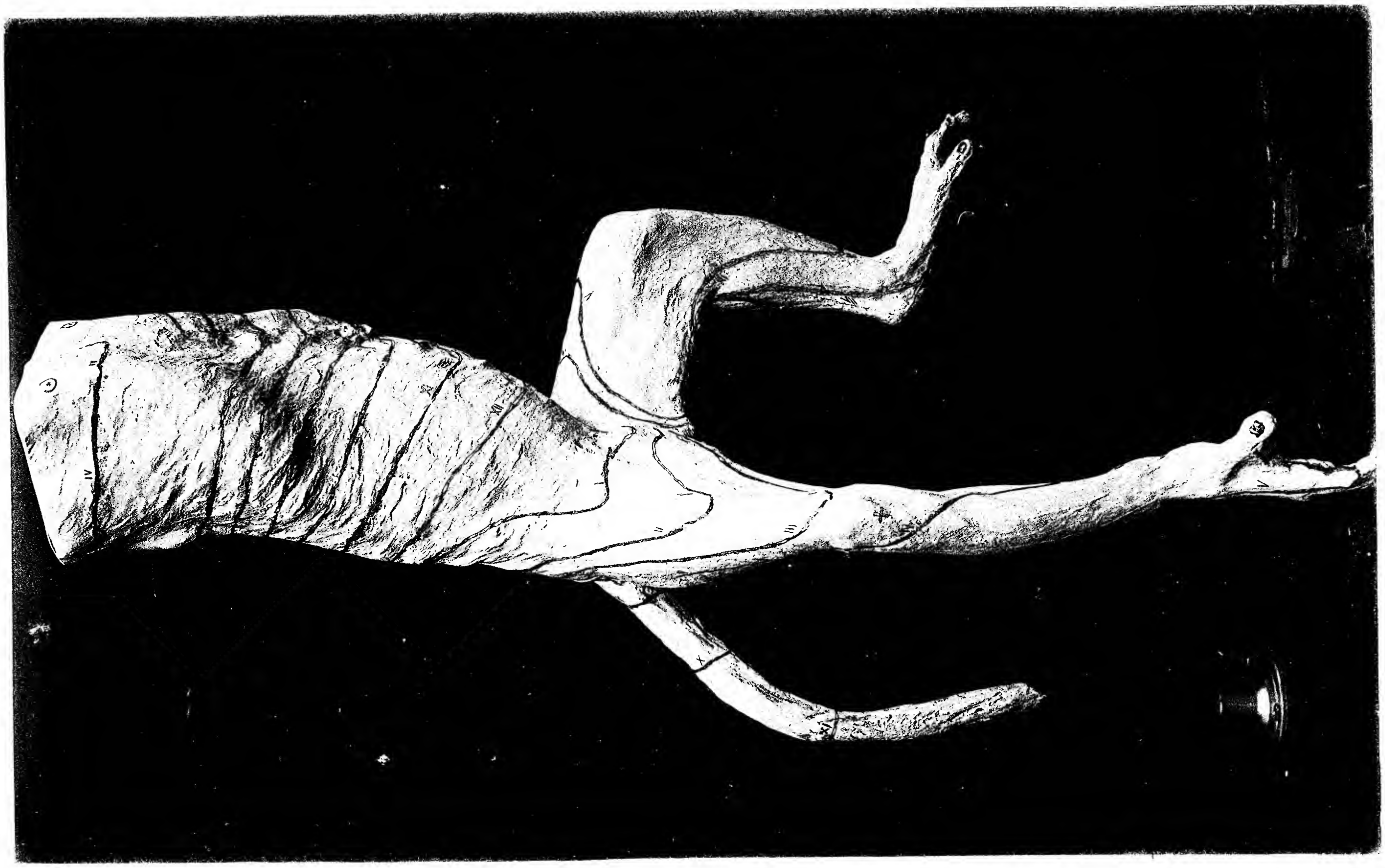

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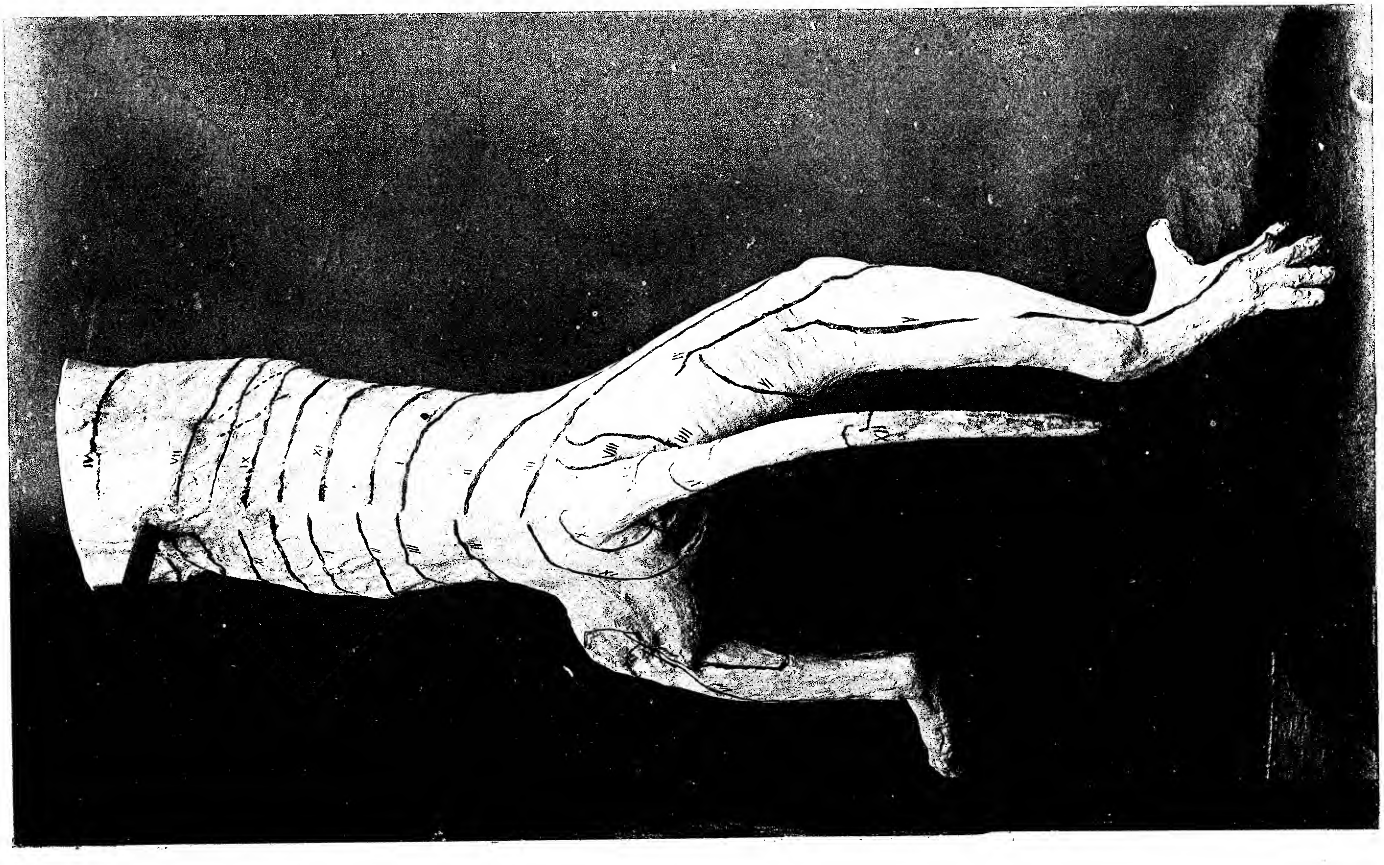

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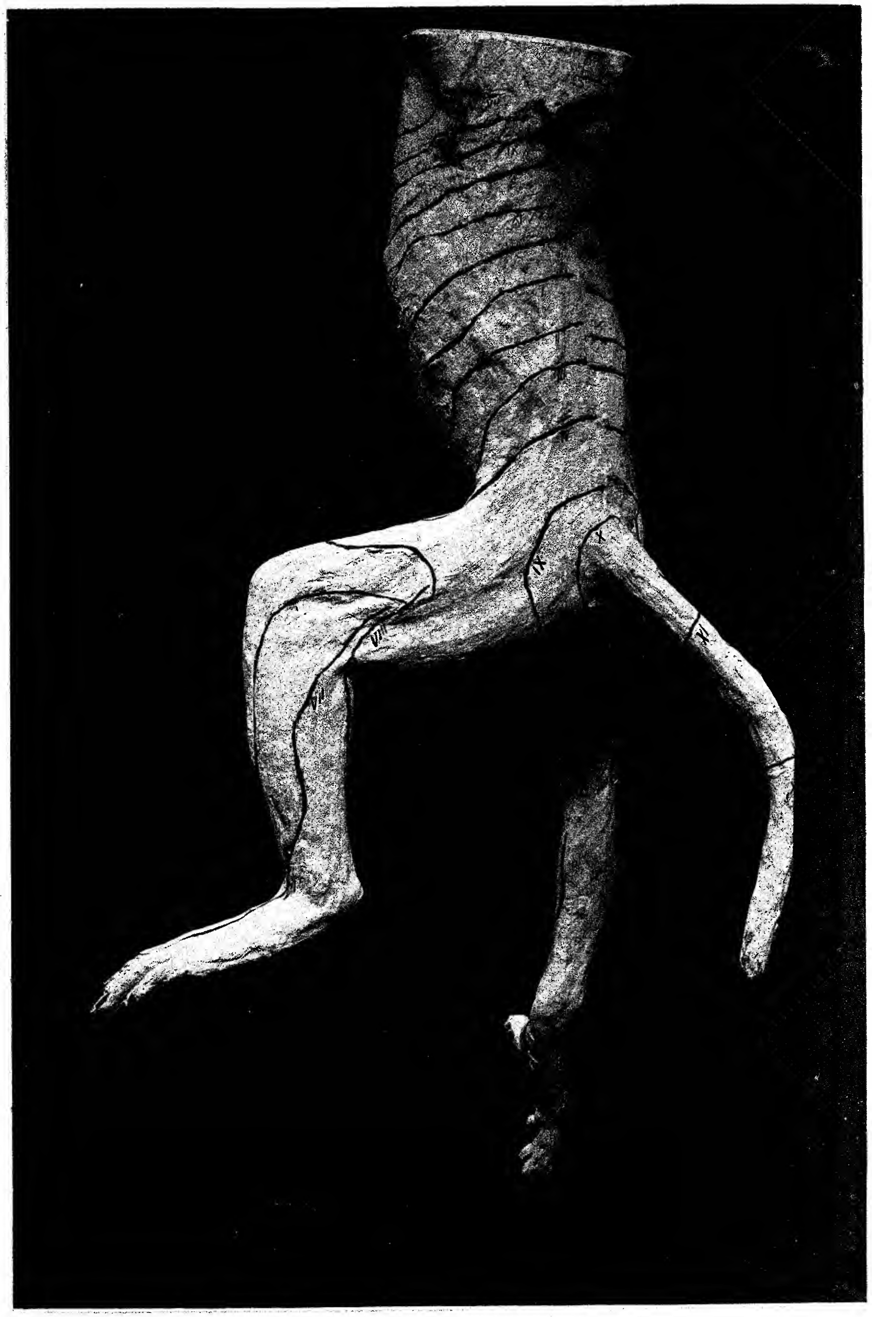

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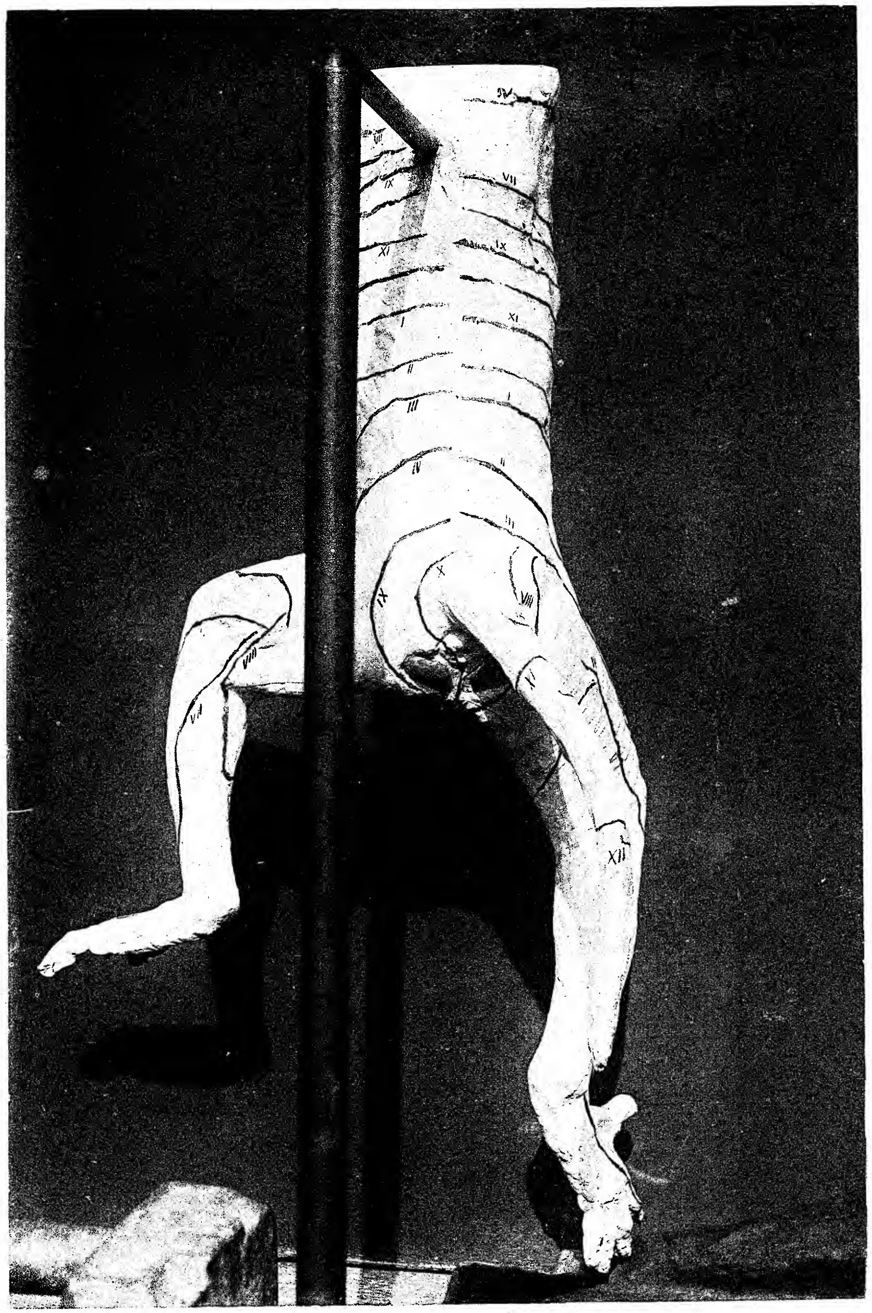

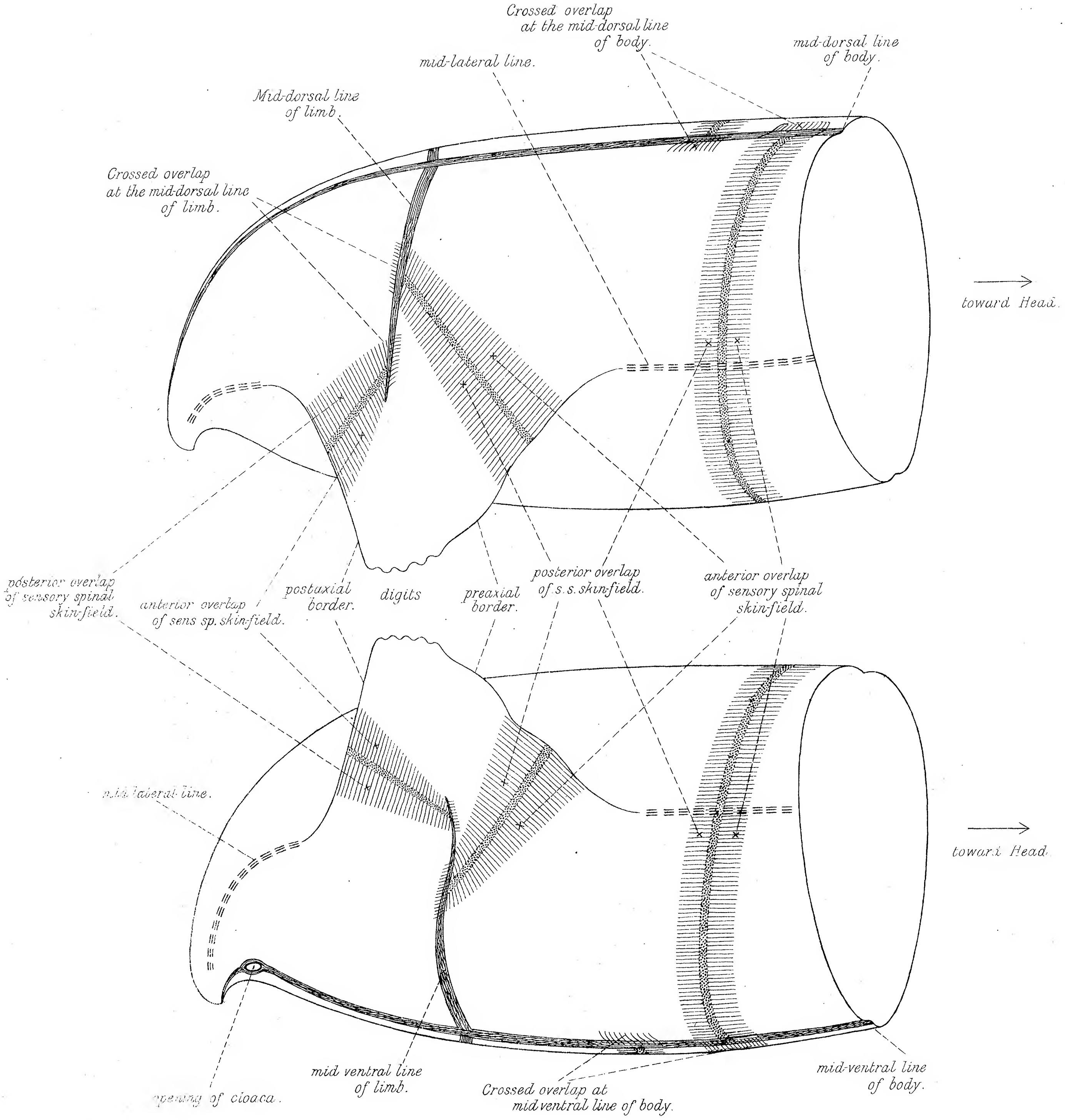
Crossed overlap at the mid-dorsal line of body.
mid-dorsal line of body.
mid-lateral line.
Mid-dorsal line of limb.
Crossed overlap at the mid-dorsal line of limb.
toward Head.
posterior overlap of sensory spinal skin-field.
anterior overlap of sens sp. skin-field.
postaxial border.
digits
preaxial border.
posterior overlap of s. s. skin-field.
anterior overlap of sensory spinal skin-field.
mid-lateral line.
toward Head.
opening of cloaca.
mid ventral line of limb.
Crossed overlap at mid ventral line of body.
mid-ventral line of body.

Cambridge Engraving Company.

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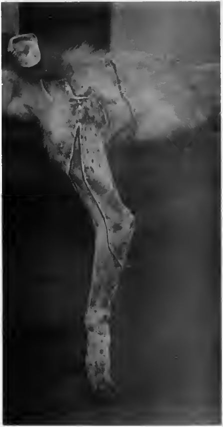

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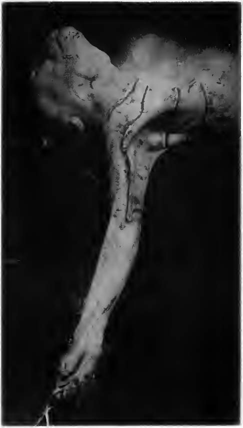
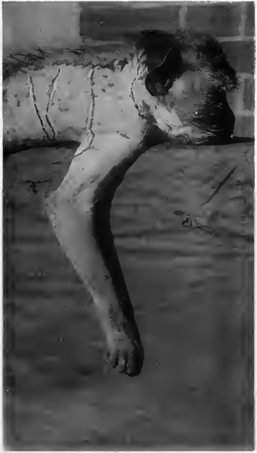


PLATE 42.

Fig. 1. The IInd thoracic field, with posterior edge of IVth cervical, and anterior edge of VIIth thoracic.

Fig. 2. The IIIrd thoracic field, with posterior edge of IIIrd cervical, and anterior edge of VIIth thoracic.

3.



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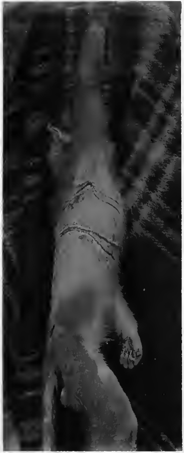

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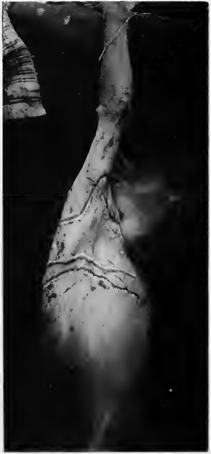

PLATE 43.

Fig. 3. The IVth thoracic field, with posterior edge of IIIrd cervical, and anterior edge of VIIth thoracic.

Fig. 4. The VIIth thoracic field, with posterior edge of IVth thoracic, and anterior edge of Xth thoracic.

Fig. 5. The IVth thoracic field, with the anterior edge of the VIIth thoracic.

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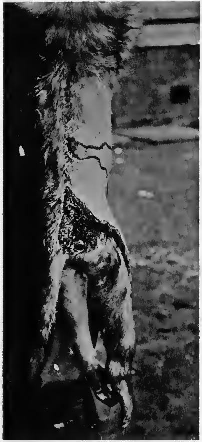

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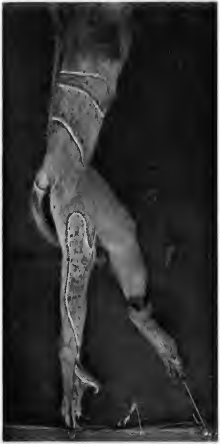

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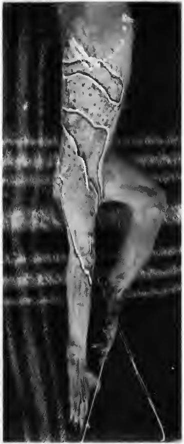


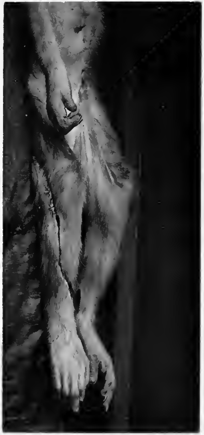
PLATE 44.

Fig. 6. The IIIrd post-thoracic field, the posterior edge of the XIIth thoracic, and the anterior edge of the XIth post-thoracic. The position of the last ribs is marked.

Fig. 7. The Ist and Vth post-thoracic fields, the posterior edge of the Xth thoracic, the anterior edge of the XIth post-thoracic.

Fig. 8. The XIIth thoracic and IVth post-thoracic fields, and the posterior edge of the IXth thoracic. Position of the lowest ribs is marked.

9.



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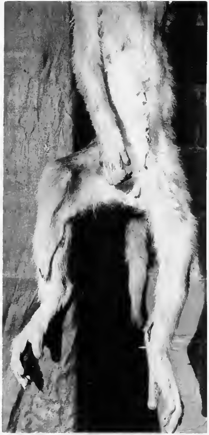

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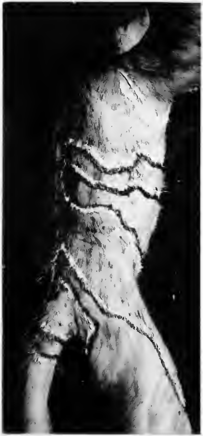
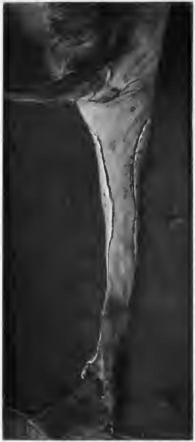


PLATE 45.

Figs. 9 and 10. The VIth post-thoracic field.

Fig. 11. The IIIrd and IXth post-thoracic fields, with the posterior edge of the XIth and XIIth thoracic, and anterior edge of XIIth post-thoracic. Position of lowest ribs is marked.

12.



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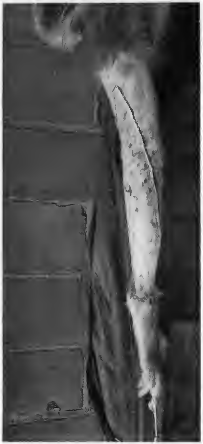

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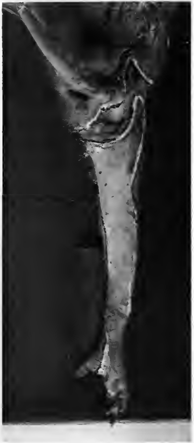


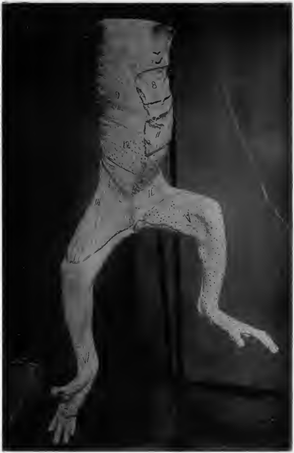
PLATE 46.

Fig. 12. The Vth post-thoracic field.

Fig. 13. The VIth post-thoracic field.

Fig. 14. The VIIth post-thoracic field, posterior edge of IIIrd, posterior of Xth post-thoracic.

15.



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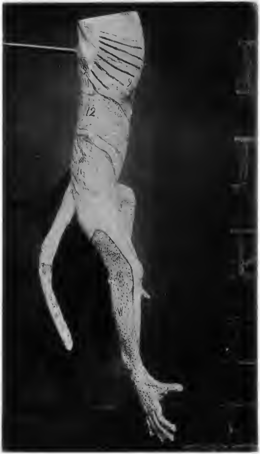
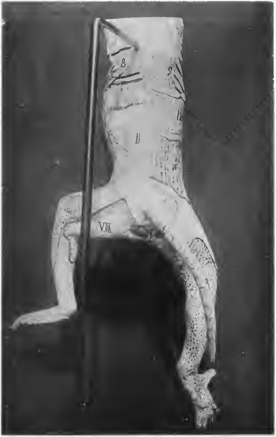


Figs. 15-19 inclusive. Skin-fields from the IVth thoracic backwards, shown on a plaster cast of a young *Macacus rhesus.* The *mid-dorsal line of the limb* is marked in on the left thigh in fig. 19.

17.



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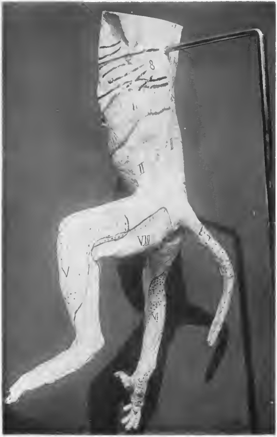

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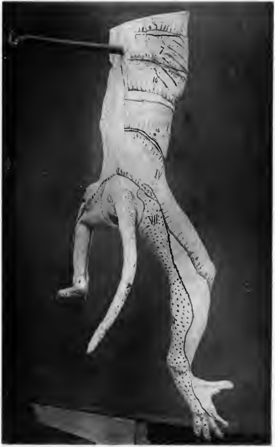

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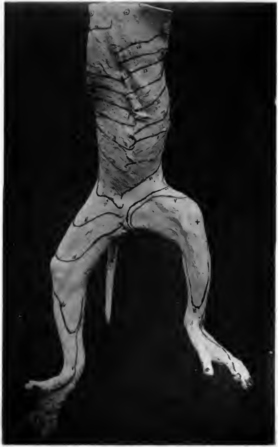
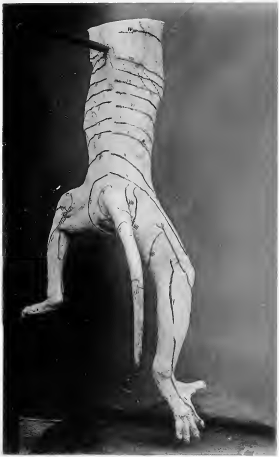


Figs. 20–24 inclusive. Similar plaster cast. The anterior borders of the skin-fields are marked on the left half of the cast, the posterior borders on the right half.

21.



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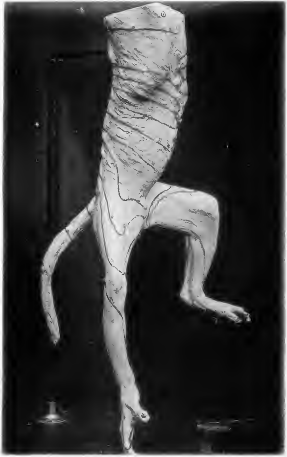

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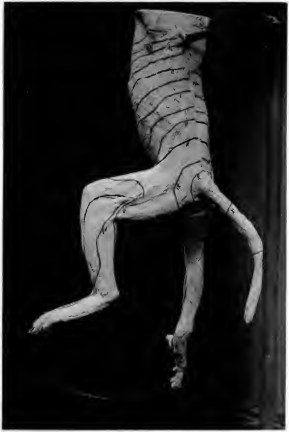

24.